SCIENTIFIC AMERICAN SUPPLEMENT

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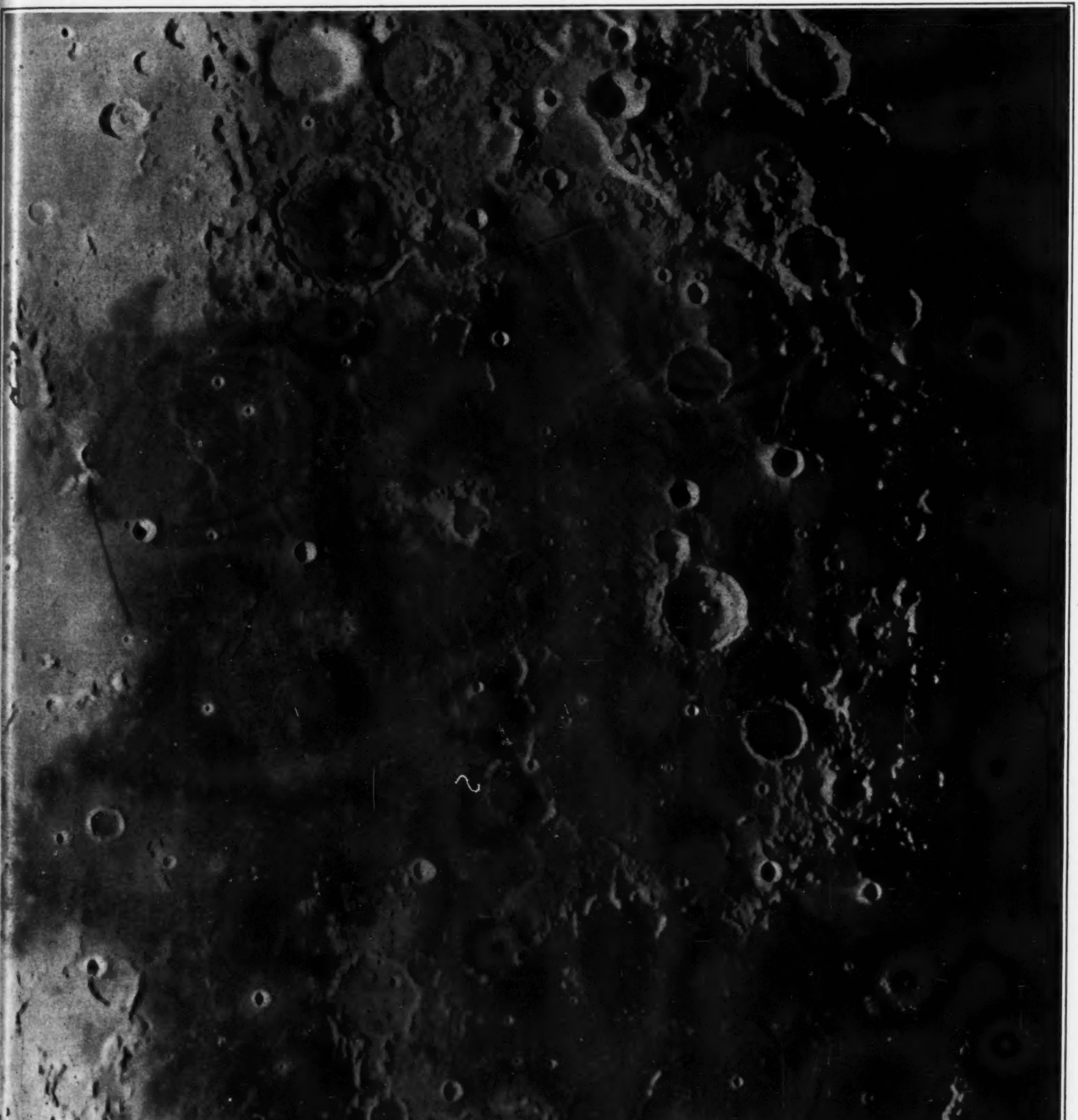
VOLUME LXXV] NUMBER 1954]

NEW YORK, JUNE 14, 1913

[10 CENTS A COPY $5.00 A YEAR



The prominent crater near the center with a craterlet within it, is Bullialdus. Terrestrial craters are of two types, those like Vesuvius and those like Kilauea. To most of us the former is the typical volcano, but the latter more closely resembles the lunar type. It has puzzled many students to account for the central peaks characteristic of many lunar craters. No entirely satisfactory theory has as yet been advanced.

The Mare Nubium.

GLIMPSES OF THE MOON.—**[See page 375.]**

Is Our Civilization Dying?*

The Evidence of History

By Sidney Low

MOST of the people who write about eugenics and kindred topics are less alarmed by the relative decline of certain countries than by the alleged shifting of the balance within these countries themselves. They contend that in England and elsewhere—perhaps to a greater extent in England than anywhere else—the better elements of the population are almost stationary, while the less responsible and degenerate classes are increasing fast. This is the foundation of a good deal of talk about "race suicide," which is very common in England and America at present. It is urged that the registration figures, taken as a whole, do not really give a true impression of the magnitude of the evil, for they fail to distinguish with sufficient accuracy between the birth-rates of the different classes. It is known, however, that the rate is falling much faster among the educated and propertied minority than among the masses of unskilled laborers. In some of the agricultural counties of England, and in the slum areas of eastern London and the great manufacturing cities, large families and early marriages still remain the rule; whereas in the favored residential areas, and among the professional and well-to-do classes, the conditions are the reverse. So we have people pointing out that, year by year, the degenerates and the irresponsibles are gaining ground at the expense of those who are mentally, physically, and biologically "fit."

The truth is, the biologists are not as yet in agreement as to the very foundations of the evolution doctrine when applied to hereditary qualities. Eugenics is still attempting to deal with this disagreement, which must be reconciled or disposed of before their study can be said to rest upon a real scientific basis. So far we are in the purely tentative stage, and we are feeling our way in a mist of uncertainty toward an explanation of the physiological and biological factors which cause the decline of nations.

If science can still only shed a flickering and uncertain light upon this subject, history might perhaps lead us to some more definite conclusions. Whatever may be going to happen in the future, it ought to be possible by systematic research and careful analysis to gain some clear indication as to what has happened in the past. But it cannot be said that the attempts made in this direction have been so far particularly fruitful. Why is it that civilizations which have risen to a certain level of security and progress are suddenly arrested or else suffer under the effects of gradual weakness and decay, until at length they sink back into complete stagnation or are overwhelmed by barbarism? Why are some epochs decadent, and why do some civilizations become decrepit or moribund? Do races, like individuals, grow old and exhibit the phenomena of senescence, and why should they do so?

These are questions to which so far no complete answers have been given, and those which have come under one's notice are very far indeed from furnishing a satisfactory explanation of the facts. Most of those who have turned their attention to them seem content with broad generalizations based upon a somewhat superficial examination of such evidence as may be available. I turn, for example, to the latest work on the subject issued by Dr. A. J. Hubbard with a distinctly inviting title.[1] I opened the book with all the more eagerness, since I had already read an admirable work by the same author on ancient dewponds and cattle-ways; but I am bound to say that my expectations were not entirely fulfilled. Dr. Hubbard is an accomplished student of history and antiquities, and what he writes cannot fail to be interesting. But he handles the large subject of racial and national decline with far less caution than he bestows on the vestiges of the neolithic age. A good deal of his essay is concerned with large assumptions as to these developments in the future which may be expected as the result of social and political tendencies assumed to be prevailing at present. This scientific and sociological clairvoyance is a kind of parlor game for literary persons which is more amusing than profitable, whether it is performed with the brilliant lucidity of Mr. H. G. Wells or adumbrated by that marvelous dialect which Mr. Benjamin Kidd regards as the language of philosophy. As to the past Dr. Hubbard tells us that the great civilizations have in turn decayed because the force that previously made for growth was over-matched by that which made for dissolution. This does not help us very much; but the writer goes on to insist: "that the phenomena which attend this change are invariable, although they appear under the most dissimilar circumstances and in ages widely removed from one another."

What, then, are these constants which give us the key to the history of humanity? Dr. Hubbard finds them in two circumstances: first, the arrest of the reproductive instinct among the higher stocks; and secondly, the increase of State-Socialism. In the earlier stages of development, pure instinct prevails and works in with the evolutionary process by adding to the numbers of the race and promoting its physical improvement through ruthless competition and the destruction of the unfit. Then, as civilization grows, reason asserts its sway, and the growth of population and the prevalence of competition are alike checked by voluntary action and deliberate design. Reason suggested that it was better for the individual to live comfortably than to be engaged in endless struggle for the preservation or even the elevation of the race. Socialism and the decline of the birth-rate are attempts to escape the stress of competition, since under the strictly individualistic system there is competition for wealth and comfort, and with a rapidly rising birth-rate there is competition, at any rate, among the great mass of the people for bare existence and a modicum of comfort. Thus, in an old and cultured community, where instinct is kept down and pure selfish reasoning asserts its sway, the tendency is to promote the socialistic or communal organization of industry, by which it is hoped that life can be enjoyed without being turned into a prolonged conflict. The conflict, of course, is most severely felt by parents with large families, so that it becomes fashionable, or seems desirable, to have a small family, or perhaps none at all. We are asked to notice that in a state of society where religious sanctions are losing their force, where the primitive instincts have declined, and where material prosperity is the universal ideal, a growing reluctance manifests itself toward the ties of parentage and even marriage. This tendency will be most noticeable among the educated and prosperous classes, so that the increase will be chiefly among the poorest and least capable elements of the population; and the more intellectual and energetic stocks, from which the leaders in politics, history, artistic achievement, and industrial enterprise have been drawn, gradually diminish and die out. The nation, deprived of those constituents which have been instrumental in securing its progress, loses its capacity and power, and either falls into disorganization, or is overcome by external foes who retain more robustness and vitality.

This is all very interesting, and more or less plausible, though not particularly new. Very much the same thing has been said by various writers, among others by Dr. Flinders Petrie, in a gloomy little essay which he published a few years ago.[2] But one would like to know how far the historic evidence, if closely examined and tabulated by scholars who know as much about history as Dr. Hubbard does of architecture, or Dr. Petrie of Egyptology, would support these large and pessimistic inferences. Both writers rest their assumption very largely on the case of the Roman Empire, that fertile subject for many sermons. They tell us, as so many other moralists have been telling us for the last two hundred years or so, that the most splendid and highly organized empire the world has ever known fell through its own internal weakness, this weakness being due to the growth of luxury, the decline of public and private morality, the ruin of agriculture, the demoralization of the proletariat by public doles, and the canker of slavery. All these things were the efficient cause of Dr. Hubbard's two constant factors in the decay of nations, namely, Socialism and depopulation. Everybody in the Roman world wanted to be comfortable, nobody was interested in the future of the race; consequently the wealthy classes became corrupt and dissolute, marriage was almost unfashionable, and one eminent living scholar has even given his authority to the statement that "the large majority of men never married at all"! The whole tendency of sentiment and thought was what Dr. Hubbard calls "geocentric," looking to the pleasant fruits of this bounteous earth, instead of being "cosmocentric," that is to say, concerned with infinity and the remote future.

As to Socialism, it is pointed out that the system of control and regulation went on growing in strength with the growth of the Empire. In the third century all trades were organized into corporations or unions recognized by the Government, instead of being only private societies as they had been before. All employees and craftsmen were bound to enter these combinations, and competition between traders was virtually eliminated. The State, by the abolition of free labor, granted a monopoly to the union, but it exacted considerable sacrifices and burdens in return. It required that a certain amount of work should be done either gratis or below cost price for the benefit of the poor. By A. D. 270 Aurelian had made unionism compulsory for life, so as to prevent the able men from withdrawing to better themselves by individual work. In the fourth century every member and all his sons and all his property belonged inalienably to the trade union, and the efforts of some men to emancipate themselves from the bondage were counteracted by enacting that any person who married the daughter of a unionist must enter his father-in-law's business. "So the Empire was an immense gaol where all worked, not according to taste, but by force." Yet we are told that the Roman understood the science of living better than we understand it; that he knew better than ourselves how to make the most of all the pleasures under the sun, from the noblest art to the vilest indulgences. This is Dr. Hubbard's summary of the matter. "History, showing us a population among whom the non-competitive system was maintained by any and every contrivance, reveals a leisured people, and corroborates the testimony of numberless ruins of baths and amphitheaters. Ease, it is true, was purchased by the loss of liberty, and it was found that the hand of the State was laid ever more and more heavily upon every man. But no mundane consideration—not the loss of liberty itself—could bring men back to a life of competition. The footsteps all lead one way; there is no sign of returning to the hard conditions of rivalry. . . . Ease was obtained for every class. Neither before nor since has pure reason been so greatly in the ascendant; never has the kingdom of this world been so splendid."

The moral, of course, is obvious, if rather trite. It was, indeed, being drawn in the Roman world itself by angry rhetoricians, sensational journalists, and bitter epigrammatists—Tacitus, Juvenal, Suetonius, Persius, and others—who insisted that no good would come of free-living and free-thinking. They, too, looked into the future, and said that Rome would collapse; which it did eventually, though not till after several centuries of prosperity, power, and exceeding welfare for a large part of the human race. However, the Roman Empire broke up at last, and Roman civilization was submerged by barbarism; and the result is commonly ascribed to the steady decline of the antique virtues, with the profound demoralization and corruption produced by the loss of liberty, the love of material comfort, and the decline of the best national stocks under the influences mentioned. "The splendor that was Rome" was bound to pass, so Dr. Hubbard thinks, because it was based on "geocentric" principles, and its ideals were fastened upon the kingdoms of this world and the glory thereof.

Whereas the "cosmocentric" civilization abides. For a proof Dr. Hubbard refers us to China. Chinese society is the most shining example of cosmocentricity. There is intolerable social degradation, with a racial persistence that can withstand all the shocks of fate and history. "So immense is the power of their unrestricted birth-rate that war, plague, pestilence, and famine cannot prevail against it. Obedience to supra-rational considerations is successful in the preservation of racial life and the permanence of civilization. It has conferred perpetuity upon the Chinese race and civilization—a civilization that has persisted so long and whose origin is so remote that no chronicle runs to the contrary. It confers upon them to-day a population of from 300,000,000 to 400,000,000." True, the condition of the vast majority of that population is described as appalling, ravaged by hunger, scarcity, the want of all the elementary comforts of life; they are ill-clothed, shockingly housed, the prey of horrible diseases. "The use of milk is unknown, and so the babe that cannot be suckled is doomed"; the mortality of children under twelve months old amounts to 80 per cent of the number born in some of the provinces, and "perhaps one female in ten is deliberately done away with at birth." The average of adult life is about fifteen years shorter than in Europe, owing to the prevalence of plague, dysentery, malaria, and other maladies, and a general neglect of sanitation and hygiene. "Every piece of injustice and maladministration is rife." The State is impotent; the Chinese are incapable of scientific research, and commonly fail in large industrial undertakings. "China is filled by a population that is brutalized by overcrowding and rendered desperate by the struggle for food." I do not know whether this is a correct description of Chineses conditions; but it is that of Dr. Hubbard, who apparently has some personal acquaintance with the Far East. Gloomy as his picture is, he is full of admiration for the Chinese "conception of cosmo-

* Reproduced from the *Fortnightly Review*.

[1] "The Fate of Empires," being an inquiry into the stability of civilization. By A. J. Hubbard, M.D. (Longmans, Green & Co., 1913.)

[2] "Janus in Modern Life," by W. M. Flinders Petrie. London, 1907.

centric duty." For, in spite of its narrowness and "the social death in life" it involves, it at least avoids the fatal error which destroyed Rome, the error of allowing Reason to prevail. "Reason is deadly to the race." Those peoples who are neither reasonable nor geocentric persist through the ages, while the great civilizations rise and fall, and the great empires fade away and die. So the Chinese, with their famines and plagues and incurable poverty, do not perish; nor, does the rabbit or the codfish.

It is an interesting comparison, this of Rome and China, which Dr. Hubbard has drawn, and we have to thank him for the suggestion, though we may not be quite clear as to his conclusions, or as to the nature of that supra-rational religious motive whereby we are to find both racial and social salvation. The theme of the decay of civilizations, indeed, is too large to be treated in the slight and superficial fashion with which it is so often approached. One deprecates particularly the free-and-easy handling of the decline and fall of the Roman Empire, and the sermons so often preached at us by hasty commentators on doubtful texts. It may be true that ancient Rome presented a close parallel to modern Europe; but one would like better evidence than the *lex Julia* and verses from irritated satirists and the stories of gossiping biographers spread over a long period of time. To quote Tacitus and Juvenal in illustration of Roman decay under Marcus Antoninus or Julian is no more justifiable than it would be to adduce Pope's *Essay on Women* as a testimony to the shocking corruption of English society in the reign of Queen Victoria. When people talk of the wickedness and weakness of Imperial Rome, they are probably thinking of the Rome of Caligula and Nero; they forget that this same decadent empire continued to exist and flourish more than three centuries longer, and nobody for centuries afterward really believed that it was dead even then. If Great Britain should be crushed by a German invasion we should probably not attribute any responsibility for that calamity to the matrimonial adventures of Henry VIII. or the licentiousness of King Charles the Second.

Did the Roman Empire, in fact, decay through internal corruption or social disorganization or the rise of rationalism and the failure of the domestic virtues? What were the real facts as to the alleged depopulation, and what the real causes? The subject has been admirably discussed by Seeck in his chapter on "Die Entvölkerung des Reiches" in his *Geschichte des Untergangs der Antiken Welt;* and what he has to say about *die Ausrottung der Besten*—the extirpation of the finer human stocks—should be of particular interest to our eugenic students. But Seeck's examination of the subject still leaves it full of unsolved problems; and when he tells us that half the population of the Roman Empire was destroyed by the plague one may suggest that perhaps physiological causes had as much to do with the decline of Rome as psychological or ethical. Nor is there any quite easy explanation of the long survival of the Græco-Roman polity and culture in the East after the collapse in the West. The decline and fall of Rome calls for a new Gibbon, a Gibbon equipped with all the apparatus of modern science as well as modern scholarship; and when his work was done it would doubtless supply us with some valuable hints upon the probabilities of "racial decay" and the *Ausrottung der Besten* in our present world. Meanwhile one may deprecate insecure parallels and hasty assumptions, as when we are gloomily warned that our fate will be the fate of Rome—not such a bad fate, after all—if we read sex novels, amend the divorce laws, ignore the Thirty-nine Articles, increase the income tax, or encourage the trade unions. It is a pity that most of our real historians are so busy with their "special subjects" that they find small time to deal with the long results and larger tendencies of the historic and political process. These surveys are left too freely to the moralists: whose morals are often better than their history.

A Tragedy of the Air

Five French Army Officers Killed in a Balloon Ascent

The air has claimed many victims in the past few years. It would be difficult, however, to parallel for dramatic effect a catastrophe which befell the spherical balloon "Zodiac," with five French military aeronauts, on April the 17th of this year. The weather was variable, cloudy, with showers, though not apparently threatening. There seemed to be no special risk in making an ascent, which was therefore started shortly after two o'clock. The balloon, considerably weighted down by the rain, rose somewhat sluggishly. Paris was crossed without accident, but with considerable loss of ballast. The entries in the log book, made at intervals of five minutes, cease at 2:35 P. M. A few minutes after this the balloon was seen at Fontenay-sous-Bois and at Nogent-sur-Marne, grazing the earth and striking all obstacles interposed in its path. Then it suddenly reascended, only to come down heavily at a point between Villiers-sur-Marne and Malnoue, where three dead bodies were found. Captain Noue and Lieutenant de Vasselot were still breathing, but died before night.

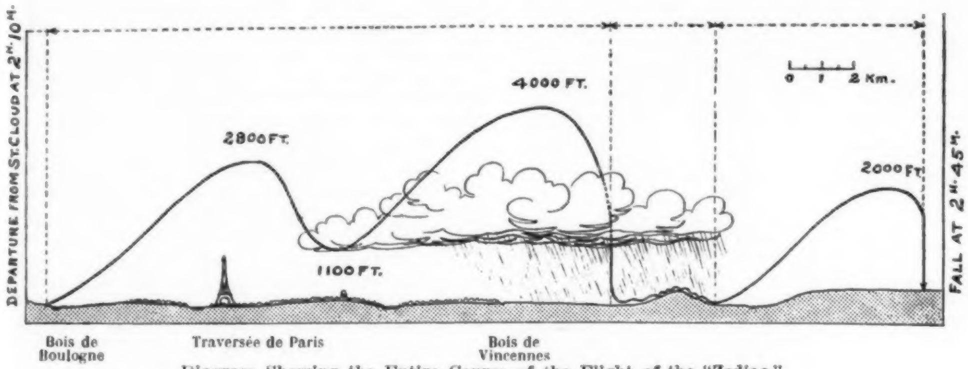


Diagram Showing the Entire Course of the Flight of the "Zodiac."

The course of events appears to have been as follows (see the letters on the accompanying diagram.

A. After having reached a height of 3,900 feet, beyond the clouds, the balloon takes a downward plunge.

B. As the balloon passes through the cloud, the rapid contraction of the gas causes its descent to become precipitate. The 220 pounds of ballast which still remained on board, according to the log book, and which ordinarily could have been amply sufficient to prevent dangerous landing, are quickly exhausted.

C. At 330 feet above the railway station of Fontenay-sous-Bois the balloon passes a crossing. The guide rope is caught on the ground, and the balloon grazes the houses of Fontenay.

D. The pilot succeeds in discarding the guide-rope, which was found on the fence of a residence. So far there had been, as yet, no severe shock to the basket of the balloon. A little farther on were found a bottle and some awnings, discarded to gain a little in buoyancy. The balloon rises a little, but unfortunately a downpour of rain and hail bring it back to the ground.

E. The basket hits a low isolated residence upon the slope of the hill. The wind velocity must have been about 30 miles per hour, so that the shock was heavy. An eye-witness at this moment observed the passengers standing upright in the car. When the balloon rose after the shock, tearing the roof and chimney of the house, there remained no visible evidence of the men on board, save an arm seen hanging from the side. The wind was high, and no cries could be heard.

F. The balloon plunges down in the garden of M. Humblot, makes a leap, tearing down a wall, and again comes to the ground in the adjoining lot.

G-H. The balloon had been followed by M. Sprengler from the station at Fontenay. He had almost reached it, when it rose again with another bound. Cries were heard at this moment, the only signs of distress from the occupants of the car, which reached human ears. After that there were no further signs of life. A little farther on, at the fort, Nogent, a military cyclist, caught hold of a rope hanging from the balloon, but was soon forced to let go.

I. The balloon crosses the quadangle of the fort, and is hurled against a wall, leaving a large blood stain. The barometer and statoscope were picked up in the grass near this point. The balloon sweeps on, leaving a track of blood drops behind it.

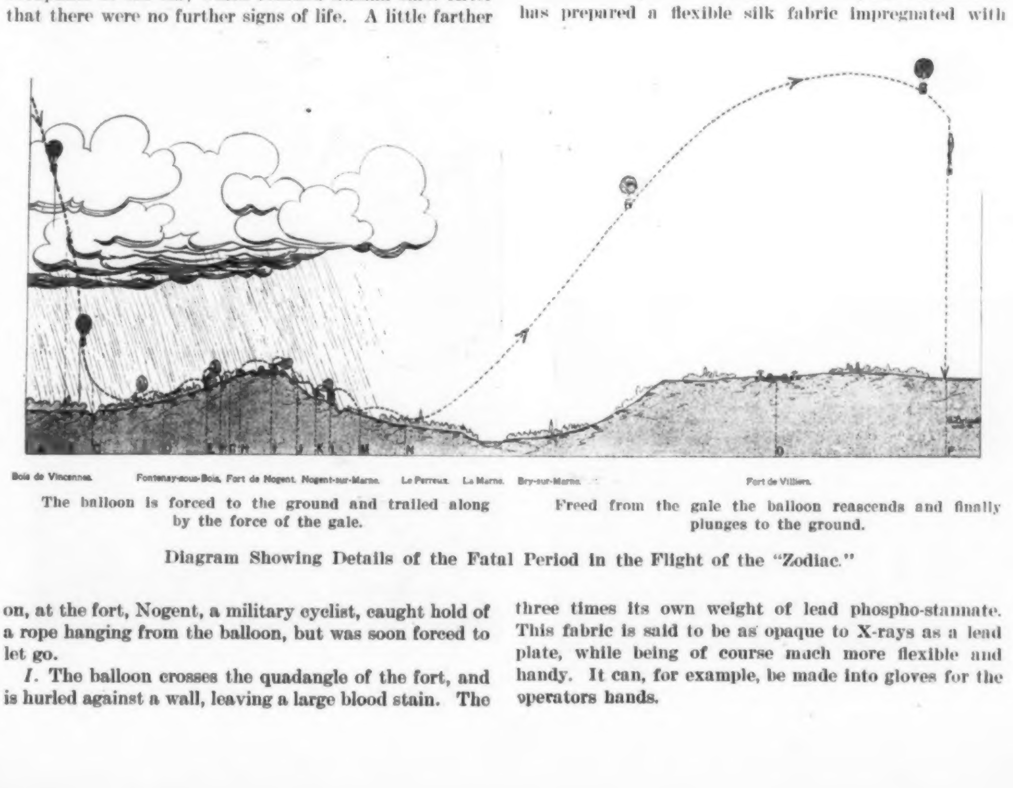
K. Here the ground forms a depression, and for a short distance the balloon proceeds without meeting further obstacles. Presently it strikes a marble cutter's shop.

L. The balloon rises again, strikes the second story of a residence, demolishes the gutter, tears the telegraph wires, and now rises in its last ascent.

O. The exact cause of the final fall is unknown. It would seem that one of the occupants regained consciousness, and, perhaps terrified by the spectacle of blood before him, drew the red cord which rends the balloon—a last resort intended to be used only within a few feet from the ground. Two artillerists at Fort Villiers state that, by the aid of glasses, they saw several passengers seeking to climb into the rope work.

P. The balloon finally collapsed and fell from a height of 1,000 feet at 2:45 P. M. The entire tragedy was played in just ten minutes, while the balloon traveled over a course of six miles.

It appears that the accident was due to a gust of the gale, which swept the balloon before it, forcing it down to the ground regardless of its buoyancy. It seems very doubtful whether any advantage would have been gained, had there been more ballast on board.—*L'Aérophile.*



The balloon is forced to the ground and trailed along by the force of the gale.

Freed from the gale the balloon reascends and finally plunges to the ground.

Diagram Showing Details of the Fatal Period in the Flight of the "Zodiac."

A Fabric Impermeable to X-rays

It is well known that persons who conduct lengthy experimental work with X-rays, and those who have occasion to make use of them in regular practise, e. g., physicians are exposed to a certain danger of injury from these rays. According to *Cosmos*, M. Bettremieux has prepared a flexible silk fabric impregnated with three times its own weight of lead phospho-stannate. This fabric is said to be as opaque to X-rays as a lead plate, while being of course much more flexible and handy. It can, for example, be made into gloves for the operators hands.

Making Steel Type*

Cutting Letters in Steel by Hand and Machine

By Chester L. Lucas

The general method of making type of type metal (tin, lead and antimony) for printing is well known, but to make type from steel so that it can be set up and used for stamping metal in the same way that printing type is used, is quite another matter. A firm of New York city makes quantities of steel type that can be set and locked in chases in the same way as regular printing type, and some of the methods used in the manufacture should be interesting to those not familiar with this class of work. In making steel type the perfect alignment, even length, uniformity of face, etc., are as necessary as for printing type. Steel, of course, cannot be cast in type form; therefore, the letters must be cut upon the type face starting from the soild steel. This type is made for stamping steel, brass and wooden novelties with makers' names, etc., and also for printing on cloth and other materials where ordinary type would not give long service. For such purposes the type can be set up and used exactly the same as ordinary type. At *A* and *B*, Fig. 1, are shown pieces stamped with this type, and in Fig. 1 separate types may be seen at *E*, *F* and *G*.

PREPARING THE BLANKS.

The stock from which steel type is made is cold-drawn high carbon steel, and the three-foot long strips come drawn very accurately to size. In making a given font, stock is selected of such proportion that all the letters may be made upon a standard size of blank, excepting the letter I which requires a narrow blank. By making a special style of M and W, the use of wide blanks is obviated. As the type is finished to a length of 0.625 inch (standard printing type is 0.918 inch high), the blanks are sawed to this length plus 0.005 inch—just enough to allow for finishing. A 5A font has 150 characters; therefore this number of type blanks is cut off, using a cutting-off fixture on a milling machine, while clamped in the special chase shown in Fig. 2. This chase is a simple outline with adjustable sides which may be keyed about the font of the type. Different sizes of these chases are used to accommodate fonts of large or small type. Keyed in this frame the type blanks are taken to a surface grinder, and while held on a magnetic chuck they are ground to a length of exactly 0.625 inch. In order to keep this size uniform, an ordinary limit gage is used for checking the lengths of the blanks. This gage is shown at *A*, Fig. 15.

ROUTING OUT THE TYPE.

The blanks, which are now all of standard length, are next locked in a special holder shown in use in Fig. 4, which is used for handling the type from this stage until ready for hardening. The blanks are set up in this box with thin spaces separating them and strips to separate the rows. The object of separating the blanks will be made apparent later. By tightening the set-screws on the sides and end of this holder the blanks are held rigidly, so that they can be machined without difficulty. While locked in this box any necessary laying out is done as shown in Fig. 4. Some of the cutting may be done without previous laying out, such letters as O, U and other easily made letters are handled in this manner. The more difficult shaped characters like R, S, and & are usually carefully laid out before cutting.

One of the machines used for routing or milling out is illustrated in Fig. 5. This is a Becker vertical milling machine specially adapted for this class of work. The box with the blanks locked in it is clamped on the table of the machine, and by means of special high-speed cutters the letters are routed out. At *A* in Fig. 3 is shown the style of cutter used almost exclusively on this work. These cutters are made of high-speed steel shaped like a diamond, as indicated in the illustration. It is obvious that the two lips of the diamond do the cutting and as the point of the cutter is sharpened chisel-shaped, it may be fed downward when reaching into the center of a letter O or similar character. These cutters are finished with an average included angle of 30 degrees. If the letters must be cut deep and narrow, it is necessary to use a cutter of less degree. At best, this work is hard on the cutters and they must be favored as much as possible, in order to keep them in good condition. It is much easier to start a small cutter like this from the side of the work than to force it to cut its depth straight downward; and it is for this reason that the blanks are separated by a space in the holder. In routing out the different parts of the work the cutter is guided by both of the feed handles. The handles are worked separately over the horizontal and perpendicular lines and simultaneously over the inclined lines. Through continued practice an operator becomes adept in its manipulation. An air blast is provided to keep the chips clear from the cutting point, and the work is done without the use of lubricant of any kind. Large cutters are used wherever possible, for they, of course, give the best service. The average cutter speed is 1,400 revolutions per minute. To keep the cutting to standard depth, the adjustable stop for the spindle is set, and the cutter is brought down to the right depth by pressure upon a foot treadle, thus leaving both hands free for the operation of the feed handles.

Hand clipping or filing is not resorted to. By relying solely upon machine work for removing the metal several advantages are gained. In the first place the bevels are kept uniform, which would be practically impossible if a file or chisel were used. Even bevels mean that no matter how deep the type is forced into the material to be stamped the impression will be even. By the use of the machine the horizontal and perpendicular lines are kept at right angles to each other, so that at the final finishing it is only necessary to smooth up the sides, which can easily be done without losing the alignment of the letter.

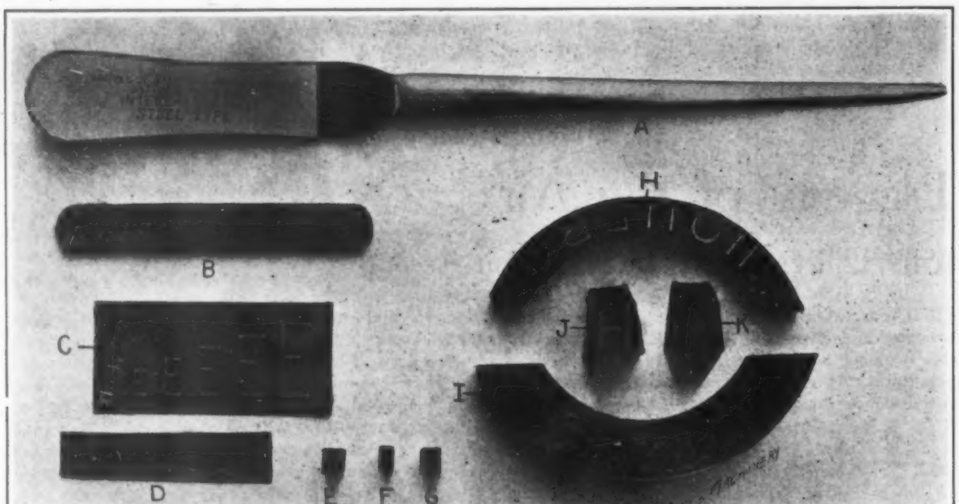


Fig. 1.—Samples of Steel Type and Work Stamped from Them.

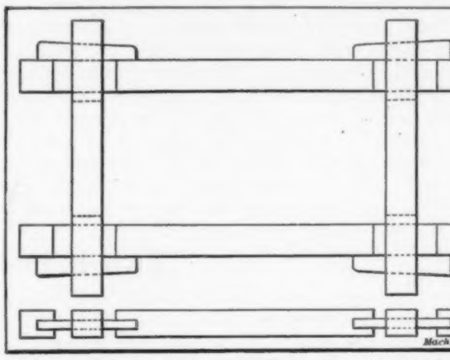


Fig. 2.—The Chase in Which the Type is Held for Grinding.

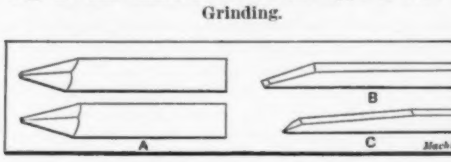


Fig. 3.—Cuter and Gravers Used in Type Making.

* Reproduced from *Machinery*.

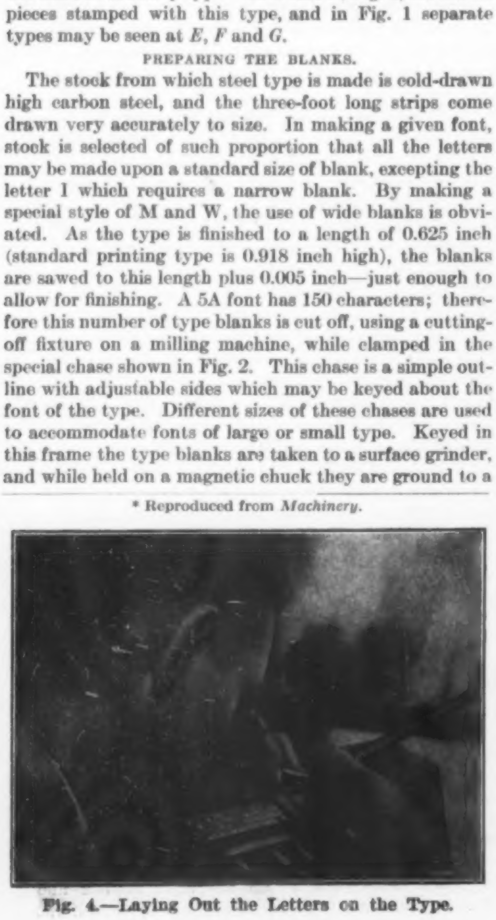


Fig. 4.—Laying Out the Letters on the Type.


Fig. 5.—The Milling Machine on Which the Type is Routed.

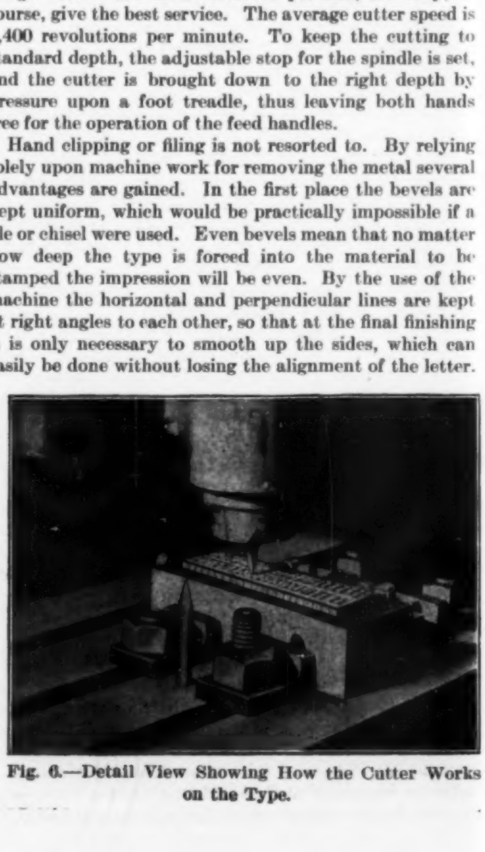


Fig. 6.—Detail View Showing How the Cutter Works on the Type.


Fig. 7.—Trimming the Type With a Flat Graver.


Fig. 8.—Taking an Impression of a Font of Type.


Fig. 9.—Using a "Spitz Tool" in Trimming.

The third reason for milling the entire letter rather than filing or chipping the outside is that the work may be finished completely in the holder, thus requiring a minimum of handling in producing the work. Referring to Fig. 6 it will be seen just how the cutter is used in routing out the type.

ENGRAVING THE TYPE.

There is, of course, a limit to the amount of work which can be done on the blanks by routing. After this point has been reached the remainder of the work must be accomplished by hand, using engraving tools like those shown at *B* and *C*, Fig. 3, for the purpose. Fig. 7 illustrates a type-cutter starting to trim up a font of type. Here he is shown with a flat graver squaring up the sides of the routed letters, an operation which requires a skilled workman. For this hand work the type is still retained in the holder, being mounted in the engraver's vise shown in this illustration. The tops and bottoms of the letters are first squared up, then the outsides of the letters are similarly treated with the flat graver, which is shown in detail at *B* in Fig. 3. Next the pointed graver, illustrated at *C*, Fig. 3, and known to the trade as a "Spitz tool," is employed for cleaning up the insides of the letters, squaring out the round corners left by the cutter and otherwise completing the work. While trimming up the type it is essential that uniform bevels be maintained, that the sides of the letters be free from irregular spots, and that the faces of the type be even; of course, the sizes and proportions of the letters must agree. Obviously, the work requires much skill, and as the metal being worked upon is tool steel the operation is especially trying.

After all the cutting on the work has been completed an impression of the letters in the holder is taken in the manner indicated in Fig. 8. The box of type is held between the vise jaws and a piece of cardboard of the proper quality is placed against the faces of the letters next to the vise jaw and pressure applied to the handle of the vise. This, of course, causes the letters to be imprinted on the carboard and by inspecting the resulting impression the workman can tell if the letters are perfectly straight, of the same size, height, etc., more readily than he could by inspecting the type itself. While it is very important that the printing surface of the type blank be maintained, occasionally it becomes necessary to face the end of a piece of type slightly. For this purpose a special facer is used, which may be seen at *B* in the illustration Fig. 15. Another case where this facer is utilized is when making up single pieces of type. This facer is a simple affair having a corner into which the blank is pressed, at the same time being held against a stop at the bottom while a file is used on the part of the blank which projects above the hardened top of the facer-jig.

After the engraver has finished the hand work upon the type it is ready to be hardened. This operation is illustrated in Fig. 13, from which it will be seen that the type is heated on a thick iron plate, using a muffle furnace. When at a proper heat, the hardener slides the pieces from the plate into a brine solution. After the


Fig. 10.—Method of Using Steel Interchangeable Type.


Fig. 11.—Milling the Perforations in a Hat Mold.

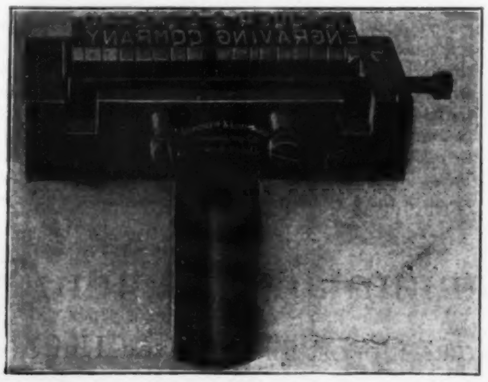


Fig. 12.—A Small Type-holder set up Reading for Use.

temper is slightly drawn the type is ready for use for stamping or printing.

USING THE TYPE.

For stamping metal articles like those shown at *A* and *B*, Fig. 1, the type is used in a foot, screw or power press, according to the character of the work. For printing on cloth or similar material, it is used in a printing press in the ordinary way. Fig. 10 illustrates a pressman setting up steel type for printing soft aluminium plates, a foot press being used for the purpose. The type-holder or chase is similar to the box in which the type is held for cutting, except that it has a hardened steel plate at the bottom and is fitted with a shank, so that it may be held in the press. A smaller, but similar holder, is shown at *D*, Fig. 15, and on a larger scale in Fig. 12. Holders are also made for stamping by hand and one of these is shown at *C* in Fig. 15. The only difference between this holder and the one shown at *D* is that it is made from a forging which is provided with an end, which may be struck with a hammer. As in the case of the holder shown at *D*, this hand stamping holder is fitted with a hardened plate at the bottom of the type-holder to prevent the type bodies sinking into the soft steel holder. One of the great advantages of using steel type rather than solid steel stamps is that different words may be set up without going to the expense of having new stamping dies cut. In addition when a piece of type becomes broken it is only necessary to insert a new piece.

EMBOSSING TYPE.

Type for embossing letters in sheet metal is also made along the same lines. Referring to Fig. 1 again, at *C* and *D* may be seen specimens of embossing by means of movable steel type. This type is made the same as stamping type, except that the letters are sunk in the blanks. The letters are laid out and routed and then finished by hand in the same manner as raised letters. For forcing the sheet metal into these letters copper "forces" may be made by striking a piece of copper into the previously set up type, or, if the metal to be embossed is too thick to permit of this being done, raised letter type, made to correspond to the sunken letter type, is used. Embossing type of this character is difficult to make. First the sunken letters must be cut, then the corresponding blanks for the raised letters must be held in perfect alignment with the sunken letters and an impression taken. The sunken letter type has, of course, been previously hardened. The steel surrounding the impression on the raised letter blanks is then routed away. By thus fitting each raised letter to its corresponding sunken letter and numbering the pairs, it is insured that good alignment will be secured. With a font of this embossing type metal articles may be embossed with any desired words or lettering.

ONE APPLICATION OF EMBOSSING TYPE.

An intersting set of embossing type was recently made by the firm referred to above, for embossing automobile lamp trimmings. The maker of automobile lamps wished to stamp the dealer's name on each lot of lamps ordered, but as the name had to be embossed on the rim of the lamp, which surface was also crowned, the dies necessary for each individual shipment were quite expensive, and of course a separate die was required for each name to be embossed. To overcome this die expense the manufac-

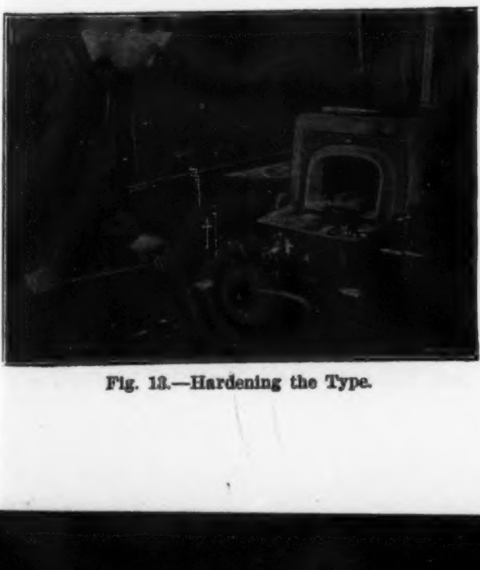


Fig. 13.—Hardening the Type.

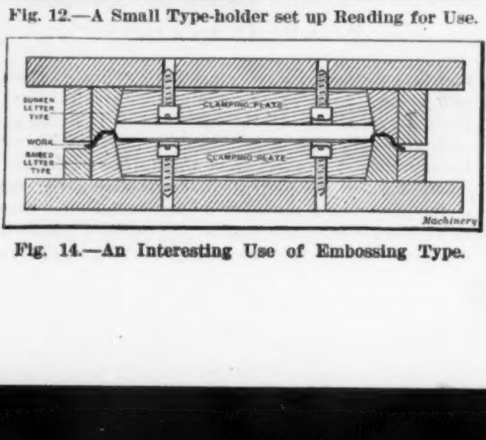


Fig. 14.—An Interesting Use of Embossing Type.

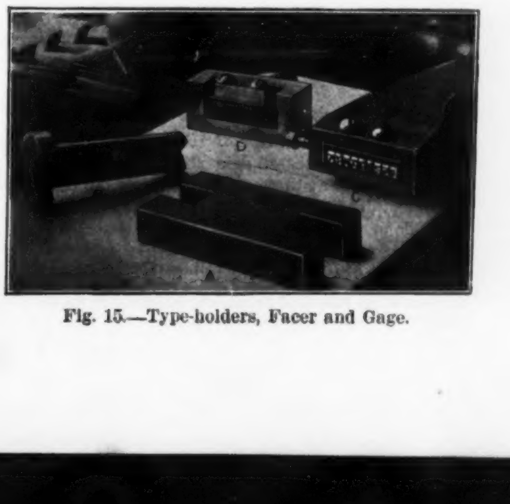


Fig. 15.—Type-holders, Facer and Gage.

turers made a stamping fixture to fit into a power press. The general design of this fixture is shown in Fig. 14, and as will be seen, it consists of two halves; the lower part is fitted to receive the raised letter type and the upper holds the sunken letter type. Suitable clamping plates may be drawn down against the beveled sides of the type. The raised letter type is set up in proper position and the location of the corresponding sunken letter type is adjusted before being finally clamped in position. The work is then treated in the ordinary manner, being laid upon the lower die and the letters embossed between the type. In making the type blanks, rings were first turned to the proper dimensions. The blanks were then sawed from these rings, being in the form of segments. Two of these pieces are shown in Fig. 1 at *J* and *K*. It will be seen that after once being equipped with these tools this method of embossing was more economical than was the case when the solid dies were used, for it will be readily appreciated that the cost of these special dies was high. Two of the solid embossing dies that were formerly used are shown at *H* and *I*, Fig. 1.

A SPECIAL MACHINE ENGRAVING JOB.

Although somewhat foreign to steel type making, the operation shown in Fig. 11 is interesting, being done on one of the Becker milling machines used for type making. The work is done on a brass shell, 1/16 inch thick, and is used in the hat-making industry. It is necessary to perforate this shell as indicated by the black marks on the work. To do this the shell is mounted upon an adjustable angle-iron, first being supported upon a wooden arbor. While in this position the cutting is done with one of the tools used for type-making. The work is turned from time to time to present different surfaces of the shell to the cutter, and while the operation is necessarily tedious, it is quite effectively accomplished on this milling machine.

The Length of Geological Epochs

Radium as the Clock of Ages

Geology and astronomy occupy, among the sciences, a peculiar position in this respect, that the geologist and the astronomer are interested in actual concrete points of time, whereas in other sciences we may study the course of events in time, but we do not as a rule inquire as to the particular concrete instant when a given event took place. In other words, in physics, for example, we may be interested in the length of time occupied by a given process, but we do not particularly care when the process occurred. The matter is different in astronomy and still more so in geology. The astronomer does not merely inquire at what velocities the various heavenly bodies move, but he is confronted with the problem: What was the position of a given heavenly body at a stated time? Or his problem may relate to the future, and he may inquire, for example, at what time eclipses of the sun will occur in the future. But the historical science *par excellence* is geology. The business of the geologist is to unravel the far remote past of the earth's history. This he has done by studying the rocks of which the earth's crust is composed, noting in particular the sequence in which the several strata have been laid down, one upon the other. To the uninitiated this might appear at first, quite a simple matter. But in point of fact the problem is much complicated through the vicissitudes which the earth's crust has undergone in the course of time. This crust is never wholly stationary but is undergoing a slow movement, the result probably of crust tides, similar to the tides in the sea, and also of other causes, such as the redistribution of material, owing to erosion and deposition by rivers. Perhaps the cooling of the earth also contributes its share in the remodeling of the earth's crust. However this may be, the fact is that the various strata of which this crust is composed do not everywhere lie simply in flat concentric spherical shells. Such an arrangement may occur here and there over restricted areas and restricted depths. But the rule rather than the exception is that the strata are thrown up into folds and sometimes turned bodily upside down. Thus the problem of determining their true sequence is anything but simple, and the geologist has developed a number of methods for attacking this problem. Of great assistance to him in the search after the earth's historic past are the fossils imbedded in the strata, which enable him, after he has studied the sequence of certain species in strata which show little or only obvious changes, to compare them with those appearing in other strata where conditions are doubtful, and to thus establish their natural sequence. The remarks made hitherto apply of course only to rocks deposited by sedimentation. Other rocks are formed by the injection of molten volcanic material through strata previously laid down. Here entirely different methods have to be employed to determine the age of the different constituents of the crust. It is not our purpose here to enter into a detailed discussion of the methods employed. It is merely intended to point out that the result of such methods as outlined above can only be to give us a rough idea of the order in which the several geologic epochs succeeded one another, without giving us more than at most an extremely crude idea of the length of these epochs in years. It is true that some estimate of this length of time might be gained from the thickness of the rocks laid down; tests in this direction have been made, but they have been rather unsatisfactory. Yet most geologists and every one interested in the results of geology naturally wishes to know how long the changes recorded in the rocks of which the earth's crust is composed actually occupied. And at the present day it is possible to form some sort of estimate in answer to this question. In this field as in so many others radium and radio-activity, which might at first sight be thought to have no relation whatever to this subject, has furnished a valuable clue to the inquirer.

Some of the most recent conclusions in this field are cited by Prof. B. Hilber in a recent number of *Die Umschau* from which we reproduce in extract some of the principal points brought out. In many minerals containing uranium, radium is found as a product of disintegration of uranium. In such minerals there is a definite equilibrium or steady condition established, the uranium being converted at a certain definite rate into radium, which in turn is converted at the same rate into other products and helium. Perhaps the expression "at the same rate" requires a little explanation. A given quantity of radium disintegrates very much faster than the same quantity of uranium would do, but when equilibrium is reached, a small quantity of radium is associated with such a large quantity of uranium, that the amount of uranium converted into radium is just equal to the amount of radium disintegrated per unit of time, so that the amounts of uranium and radium are (nearly) constant, the changes involved being in reality excessively slow.

Now the conditions of transformation of uranium into radium and helium are independent of all external circumstances. Assuming therefore that no helium escapes—an assumption which is fairly reasonable inasmuch as the total quantity of helium formed is very small—the amount of helium in a given rock must be a measure of the time which has elapsed since the birth of that particular rock. To be more exact, the time estimate just gained will represent a minimum of the age of the mineral, the estimate being too short if any of the helium has escaped. In employing this method it is necessary to use as basis only minerals which are natural constituents of the strata in which they are found, that is to say, we must exclude any possible veins or intrusions formed in a stratum subsequent to the origination of the stratum itself.

Now Strutt has determined experimentally the annual production of helium in thorianite and pitchblende. The absolute amount of helium present in a mineral depends of course not only on the age of the mineral but also on the absolute amount of radium and uranium present. In order to determine the age of a mineral by this method we must therefore consider the **relative** amount of helium. Following the terminology introduced by Strutt we shall speak of the "helium ratio" meaning thereby the number of cubic centimeters of helium per gramme of uranium oxide. The formation of one unit of this proportion of helium in a mineral requires eleven million years, which may therefore be regarded as our geological unit of time. Strutt gives the following figures as the result of his investigation:

The time elapsed from the beginning of the quaternary to the present, 1,000,000 years; from a point not precisely defined in the oligocene period, 8.4 million; from the carboniferous, 31 million; from the lower part of the carboniferous, 150 million; from the archæan, 710 million. By the same method Schlundt and Moor have computed that since the glacial epoch twenty thousand years have elapsed.

These figures have been criticised by Joly. He points out that if we divide a total thickness of sediments in the earth's crust by the 700 million years demanded by this theory, we obtain for the mean deposit a thickness two inches every four thousand years. This seems utterly inadequate to account for the actual thickness of the deposits as compared with what we know about the present rate of deposition. However this may be, other estimates seem to agree pretty well with those made on the basis of radio-activity. Thus, for instance, Mellard Reade has estimated upon geological grounds the time required for the formation of the earth's calcareous deposits, and has valued it at six hundred million years, a figure which agrees pretty well with Strutt's seven hundred million years.

Again, the twenty thousand years demanded on the radio-active theory for the time elapsed since the glacial epoch agrees with the determination made by entirely different methods by a number of geologists who have made a special study of the subject.

It is interesting now to inquire what light the conclusions thus reached throw upon the question of the rate at which the different species of plants and animals have been evolved. Summarizing the situation briefly, we might say that the flora and fauna with which we are acquainted at the present day is about fifty thousand years old. Some of the species now living are no doubt as much as one million years old. Most of the lower animals must have existed at an earlier period than this. According to Orbigny, the entire living world must have been completely replaced by a new species in all some twenty-seven times since the beginning of the world. (Lyell, on the other hand, places the estimate at twelve times.) Judging from the helium ratio in certain quaternary lavas in the Laacher Lake, 20 per cent of the crustaceans living to-day were in existence one million years ago. Assuming the same rate of change to have continued uniformly all the way back to the Eocene period, we arrive at the conclusion that 3 per cent of its crustaceans are living at the present day.

As for the age of the human species, it would appear that the earliest man known, the Heidelberg man, lived about one million years ago. Men of the type such as we know him to-day, appeared on the scene considerably later.

The Uranium and Radium Situation*

A Great Opportunity for the United States

By Charles L. Parsons

Some months since, rumors reached the U. S. Bureau of Mines of an increased demand for carnotite ores from Colorado and that these ores were being shipped abroad in some quantity. Further, it was reported that the methods of production involved large losses of material and that methods for concentrating low-grade material now being thrown on the dump were greatly needed. Accordingly, Messrs. R. B. Moore and K. L. Kithil were assigned to the task of investigating the situation with headquarters at Denver, where the Bureau established a laboratory for the purpose of investigating the rarer metals occurring in the western part of the United States and problems bearing upon the prevention of waste and increased efficiency in the mining industry. The surprising conclusion has been reached that while all the radium placed upon the market in the last few years has been produced in Europe, a large portion of this output has come from American ores.

Radium institutes have been established in Austria, France, Germany and England, a European science and industry have been developed from American radium ores and even the uranium present with the radium has been manufactured into marketable condition only in

*Paper presented at the annual meeting of the American Chemical Society, Milwaukee, March, 1913, by permission of the Director of the Bureau of Mines, and published in the *Journal of Industrial and Engineering Chemistry*.

foreign countries and returned in finished condition to our own. American hospitals and physicians have been forced to procure from abroad such radium as they could afford for experimental purposes, and investigations in our governmental and university laboratories of the wonderful properties of radium and their possible application to the eradication of disease and the development of industry have been hampered by the almost prohibitive prices at which the finished material is held.

While the Austrian government, realizing the untold possibilities of the radium ores of St. Joachimsthal, has purchased the mines, put their output under direct governmental supervision, and has entered into an arrangement whereby this ore is worked up in co-operation with the Vienna Academy of Sciences for experimental purposes in a carefully administered radium institute, America has allowed her large and much greater resources to be exploited on a basis which wastes perhaps irretrievably a large portion of the material mined, and has exported carefully selected ores at a price by no means commensurate with their radium value if worked up at home.

Even before carnotite was exported, pitchblende of the highest grade was sent out of the country at a time when the world's radium output was supposed to be coming from Austrian ores. At least 20 to 25 tons of high-grade pitchblende have been sent out of the country. Within the last two years, however, foreigners have realized the value of our carnotite resources, and most of the radium that has been exported has gone abroad in this ore.

During the last year, carnotite was produced carrying 28.8 tons of U_3O_8, from which 8.8 grammes of radium chloride or 11.43 grammes of radium bromide could be obtained. Practically all of this ore was shipped abroad for the extraction of radium. The value of the radium salts extracted would be $528,000 at the minimum market price. The total supply of radium salts from all other sources including the Austrian mines was probably not more than 3.65 grammes of radium chloride, basing the production of the Austrian mines for 1912 upon that of 1911 which is known.

Pitchblende, the richest of all uranium minerals, is composed mainly of uranium oxide but also carries lesser quantities of a large number of other substances. It has been found in small quantities in Connecticut and in the feldspar quarries of North Carolina. Practically the total American output has come from the mines in Quartz Hill, Gilpin County, Colorado. The mineral is a heavy, black substance which can be readily identified by any one by suspending a sample of the pitchblende above a photographic plate wrapped in black paper and kept in the dark for a few days with a key or other metal object opaque to radium radiations placed between the sample of ore and the plate so that when the plate is developed a shadowgraph will identify the ore. Pitchblende may carry as high as 80 per cent uranium oxide, although the average ore is not nearly so rich.

Carnotite is a yellow mineral consisting mainly of potassium uranyl vanadate but containing also small amounts of barium and calcium compounds. Being a uranium mineral, as is pitchblende, it of necessity carries radium, although it has not yet been definitely established that the uranium and radium are in equilibrium as they are in pitchblende. However, it is known that in our western carnotite the amount of radium is not far from the equilibrium ratio and in the calculations given above an allowance of 10 per cent has been made to cover this possible deficiency.

While carnotite is known to occur in smaller quantities in other States, the more important deposits are scattered over a considerable area in Colorado and Utah, embracing Meeker and Skull Creek, Colo., Green River, Thompson's, Moab, Richardson, Table Mountain, Pahreah, and other places in Utah. The largest proportion of the ore, however, has been produced in or around Paradox Valley in southwest Colorado, from which it has to stand long hauls by pack animal or wagon to the railroad. Carnotite always carries vanadium as well as uranium and radium, but is purchased almost wholly on its radium content, comparatively little being allowed for the vanadium present.

The ore, consisting of a fine-grained sandstone containing yellow pulverulent carnotite, occurs in pockets and is easily mined. As ore below 2 per cent uranium oxide cannot at the present time find a market, a considerable portion of the ore has been thrown on the dump and is now being wasted, as material of lower grade has to be discarded on account of the long haul and the fact that European buyers have set this standard as to quality. Ores of higher grade are sometimes obtained but they occur only in small pockets and it is generally advisable to mix these high-grade ores with ores of somewhat lower content in order to increase the marketable output. Ore of 2 per cent uranium oxide is now worth approximately $75 per ton f. o. b. New York. In the mining of these carnotite ores, it is probable that 5 tons of material capable of concentration are thrown upon the dump for every ton that finds its way to market. To develop methods for concentration of these ores and save the valuable material now wasted is one of the problems before the Bureau of Mines with fair prospect of a successful conclusion.

It is difficult to estimate the total amount of radium that has been produced up to the present time, but it is quite certain that if the ores which have been mined in this country and abroad and sold for radium production have been actually worked up into this material, there is now in existence something like 40 grammes (1¼ ounces) of radium. The price of radium salts varies somewhat. In large quantities it has been $60,000 per gramme for both radium chloride and radium bromide, although the latter contains less metallic radium in proportion to its weight than the former. It should be remembered, therefore, that it is more advantageous to purchase radium chloride than radium bromide. In small quantities the average price has been $80,000 per gramme which represents about $2,250,000 an ounce.

The figures given show very plainly that the United States has taken the palm from Austria as the radium-producing country of the world. Very few people have been cognizant of the fact that the United States has such deposits within her borders. Up to the present time very little interest has been taken in the matter, and only one firm has engaged in the extraction and refining of radium in this country—a condition which is deplorable. This firm has not yet entered the radium market.

Practically every ton of ore mined in 1912 went abroad, and as the American deposits are far from being inexhaustible we are rapidly depleting our own reserve and are shipping from the country material which cannot be replaced and which is of great value and of unknown possibilities.

The application of radium are still too little understood to admit of definite statement. Its discovery and marvelous properties have already changed our ideas regarding the constitution of matter, and scientific investigation will undoubtedly lead to valuable results which we cannot now even foresee. Altogether too many incorrect statements and vague speculations have been placed before the public as to its use in medicine. A recent report of the London Radium Institute and the many articles emanating from minor laboratories experimenting in the application of radium to therapeutics all tend to show, however, that it has a real value, the certain application of which must await further experimentation. In the meantime no credence should be given to the many stories that are sure to be printed, unless they are backed up by the highest medical authority which will always give publicity with caution. The best medical authorities appear to agree that, up to the present time, radium has not been proved to be a specific for any disease, although it has been shown to be helpful in many cases. The outlook for its future application to certain diseases not easily treated otherwise is decidedly encouraging.

Apparently no uranium is worked up in the United States, but according to statistics gathered by the division of mineral resources of the U. S. Geological Survey, about $14,000 worth of its oxides and salts were imported into the United States in 1911. It is one of the few materials shipped abroad as ore and returned in manufactured form.

A preliminary report on uranium, radium and vanadium by R. B. Moore and K. L. Kithil will soon be issued by the Bureau of Mines. This bulletin describes the carnotite deposits of Colorado and Utah and the pitchblende deposits of the former State. It also contains detail, of which the foregoing is simply a general summary, which cannot fail to be of value to all those interested in our mineral resources and their ultimate development.

Glimpses of the Moon*

Signs of Volcanic Action and Vegetation

By Edward Vincent Heward

Illustrated with photographs taken at the Yerkes Observatory

It is a relief to the weary soul seeking rest from the strain and stress of modern life to turn the thoughts now and then toward the calm sublimity of the heavens. The busy haunts of men are soon left far behind, and the mind untrammelled soars aloft to a realm where, "There is neither speech nor language; but their voices are heard among them." An infinite peace descends upon the Earth; the curtains of the heavens unfold, disclosing their hidden glories—the clustering constellations, the twinkling stars extending far into the mysterious depths of the Milky Way; and the Moon in her season exhibiting her varying phases from slender crescent to full round orb. At such moments the thoughts wander eastward, to the land of hoary tradition, where Earth's early inhabitants first awoke to the wonders of the starlit firmament. Their conception of "things seen in the sky," though crude, were to them downright realities, for they had in full perfection the faculty of childhood of making everything out of anything, and believing with a large and implicit faith in the creations of imagination. The pathless comet, with shaggy mane and flowing garments, was a harbinger from the gods heralding the decrees of offended deity, and the flash of meteors athwart the sky told of warfare raging among the powers above. Out of these primitive impressions there grew a wealth of myth and marvel that has made their conceptions of the heavens an inexhaustible repertory of legends and superstitions for all succeeding generations.

But uplifted admiring eyes greeted the softened splendors of the Queen of the Night as she sailed forth, calm in majestic radiance, and held sway amid the host of heaven, whose coming and going, because of their regularity, inspired confidence and repose. We should, however, be led far from our scope and purpose were we to dwell upon the alluring theme, or notice a tithe of the graceful stories woven about the—

Orbed maiden with white fire laden,
Whom mortals call the Moon.

We may touch but lightly on these things as we pass on to consider the truths the telescope has revealed to the patient interrogations of the astronomer. The physicist, indeed, tells us that she is the veritable offspring of the Earth, born in the days when Earth was young, whirling in giddy flight about her lord, the Sun.

And this child of the Earth has a history that carries the thoughts back to the old-world scenes enacted on the plains of Chaldea, where the priest-astronomer, on his terraced pyramid of Belus, casting an eagle glance athwart the heavens, marks out in bold outline the signs by which we to-day recognize the constellations.[1] Little did he dream while devising his method of foretelling eclipses of the Moon that he was observing for far-distant posterity; that his labors were laying the foundation of a structure from whose summit the heavens would be gaged and their mysteries unravelled.

Glancing along the opening vista nomadic tribes appear, ranging the trackless plains of Shinar, who look upon the Moon as a friendly guide shedding a mild radiance on their wanderings by night, seeking fresh pasture for their flocks. Well might they gaze in mute astonishment upon the celestial scene, and note the movements of the Moon and the heavenly bodies. In course of time the Moon became the goddess Ashtoreth, and the bride of Belus, the Sun-god, and temples were erected in her honor in the land of Ur, the birthplace of Abraham. Here she was worshipped under the names of the Queen of Love and War, or the Bright One. We listen in thought to the priests chanting her praises to the tinkling of cymbals. But who shall lay bare the mystery of Isis, on whose image is engraven, "I am that which is, has been, and shall be. My veil no one has lifted?"

Ages roll by in silent forgetfulness; a new era dawns upon the world of thought, and gradually the mystic web untutored vision had cast about the Moon fades away. Careful inquiry pierced the veil, revealing glimpses of another world full of marvelous possibilities, a world peopled, it might be, by living, breathing, intelligent beings akin to ourselves. A new field was thrown open for speculation, wherein imagination found refuge from prosaic fact with the poet and the romancer, who vied with each other in weaving stories of a lunar Arcadia.

The subject became much too fascinating to be left entirely to the dreamer of dreams. Men of science, with primitive spy-glass in hand, refused to believe that the new world just breaking upon their amazed vision was a lifeless globe. They reasoned that the Moon is

* Reproduced from the *Fortnightly Review*.

[1] The oldest existing representation of the constellations is that on the Babylonian black stone in the British Museum. The zodiacal signs found in India are now admitted by all Sanskrit scholars to be of modern date. Perhaps about the beginning of our era.

The Mare Serenitatis and the Palus Putredinus.

These two expanses are separated by the Appenines with peaks twenty thousand feet high, casting shadows ninety miles long at sunrise and sunset. At the bottom is the lunar Caucasus and the Alps. The three enormous craters constituting a group by themselves are Aristillus, Autolycus and Archimedes, which last is fifty-two miles in diameter.

The Mare Imbrium.

The enormous crater at the bottom, that looks not unlike a circus ring is Plato, which is sixty miles in diameter. The floor of the crater is studded over with numerous small volcanic cones. These craterlets have been studied at different times very carefully; yet no two studies agree on their exact number. This Prof. Pickering considers evidence of eruptive activity.

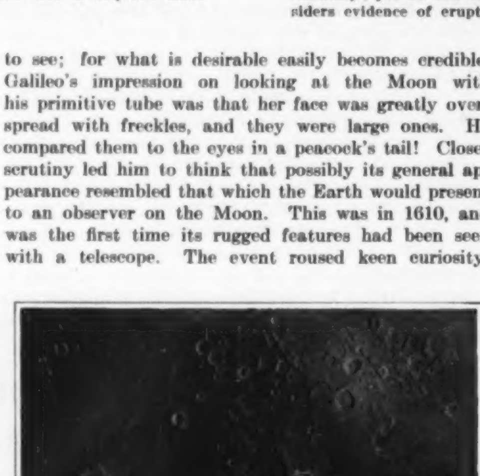
similarly circumstanced to the Earth, made up, no doubt, of similar materials; the Earth is inhabited, why, then, should not the Moon also be inhabited? A good glass and keen eyesight, aided with just a little imagination, saw the outlines of mountain ranges; therefore must there be valleys, diversified doubtless with sylvan scenery. These things being so, does it not follow that there must be rivers, seas, and oceans; consequently, blue skies flecked with cloudlets? Its mountain crags, indeed, may afford foothold for many a baronial mansion, whose lord may rule over his liegemen in true feudal fashion. In the fulness of his newborn belief one enthusiast (Butler) declared that he had seen an elephant in the Moon! And in those days no one could say him nay. Nor for many long years after would it avail to say that all the elephants in Africa if transported to the Moon and herded together would hardly make an object big enough for detection on Earth. A telescope magnifying a thousandfold would still leave our satellite 240 miles off, and anyone can judge what could be made out of some of the largest and loftiest buildings on Earth—say the great pyramid of Egypt—at that distance.

Here we touch an element of human activity always present where the view is obscured by the dim or doubtful; the personal equation. It is not always easy to resist the influence of those who, inspired with a love of the marvelous, tell of wonderful things about to happen, or that really exist all unknown to the rest of the world. Their child-like belief in creations of the imagination are apt to carry us away, until something tangible is reached. But everyone admires the genius that throws a halo of romance along the darkest path—until the light of truth breaks the spell.

There are others who have a wholesome dread of whatever tends to cast doubt upon old-established beliefs; who will not surrender their faith in the founders of science for the vagaries of a new generation bent upon seeing things which the telescope does not really show. Is it not enough that Sir Isaac Newton should have said that comets, for example, are solid, compact bodies like the planets? Why, then, accept without proof the new theory that they are made up of an aggregation of meteor-stones?

Then we have the orthodox astronomer who, caring only for pure science, recognizes that progress is not so much of flights of genius as sustained, patient endeavor. He preserves the even tenor of his way undisturbed by the over-exuberant who find traces of man's handiwork in the Moon or in Mars; nor does he heed the backward ones who contentedly lean on the past.

The telescope is a great disturber of fine fancies and old beliefs. Before its piercing eye visions of men in the Moon melt into air. In its infancy, however, it lent form and color to the hazy and indefinite, helping imagination to see and picture—the things it wished to see; for what is desirable easily becomes credible. Galileo's impression on looking at the Moon with his primitive tube was that her face was greatly overspread with freckles, and they were large ones. He compared them to the eyes in a peacock's tail! Closer scrutiny led him to think that possibly its general appearance resembled that which the Earth would present to an observer on the Moon. This was in 1610, and was the first time its rugged features had been seen with a telescope. The event roused keen curiosity;



The Mare Serenitatis and Tranquillitatis.

The great dark patches on the moon are the so-called "seas" (Maria). They cover fully one third of the moon. Not water, but oceans of lava wash their shores. Among the most important of the smaller formations upon the moon and characteristic of the Maria are the rills—gigantic cracks in the lunar surface, sometimes several hundred miles in length by one or two miles in width.

a vivid expectation of new knowledge about the Moon stimulated ingenuity and skill in the construction of optical instruments. It is noteworthy that the name of Thomas Harriot stands among the first to adopt and improve upon Jansen's contrivance for magnifying distant objects. He had received one of the new instruments from Holland, and at once set to work grinding lenses, and with a success that enabled him to produce three telescopes which were considered to be, in some respects, better than Galileo's. Unhappily, at this stage Harriot's health failed him, and his work was soon forgotten. Sir Isaac Newton's six-inch reflector is well known, and still treasured in the library of the Royal Society. Acting on an original system, he constructed a telescope which reduced the apparent distance of objects thirty-nine times. Now that the method of making magnifying glasses was understood, improvements in telescopic power were rapid and numerous. Among the many who contributed to the advancement of optical science the names of John Dollond, of Spitalfields, and James Short, of Edinburgh, may be mentioned. Dollond, in 1758, invented the achromatic lens, removing thereby the chief obstacle to the development of the powers of refracting telescopes; while Short was without a rival in the construction of reflectors; he brought the concave mirror system to unexampled perfection. The most notable improvements in enlarging their range and increasing their space-penetrating power were achieved by Sir William Herschel, whose energy and inventiveness mark an epoch in the construction of telescopes. His efforts culminated in the gigantic forty-foot instrument completed in August, 1789, by means of which he discovered two Saturnian and two Uranian moons.

Johann H. Schröter had the good fortune to secure one of Herschel's telescopes, with which he made such good progress in the topographical survey of the Moon's leading features that his systematic plan of observation was generally adopted by astronomers occupied in lunar exploration work. His inquisitive eye was soon arrested by an appearance of dark lines running across a great part of the Moon's surface, of a character resembling the thread-like lines occasionally seen when observing Mars, and which are commonly called "canals." Schröter calls his lines "rills." In the course of several years' observation he came upon eleven, but the number has now reached about a thousand. They are wholly without terrestrial analogy, nothing like them in number, size and length is found on the Earth, except, perhaps, the great Canons of Northwestern America, the largest of which is 550 miles long. Obviously they are clefts in a rocky surface, differing in length and breadth; while some are a hundred yards deep others are five hundred yards deep, and about two miles across. One of the most remarkable of these is found in the part marked in modern maps of the Moon, Oceanus Procellarum, or Ocean of Storms, near the mountain called Aristarchus, famed for the brilliance of its central peak. It terminates in a ringed plain named Herodotus. These clefts strike out in straight, curved, and branching tracts, varying in length from a few miles up to 150 miles; some cleaving mountain walls, some forming a network of intersecting clefts or cracks. In all probability they owe their origin to a process of contraction

of the Moon's surface going on during the cooling stage, for her radiation of heat would be at a much more rapid rate than the Earth's, whose surface is protected by a dense vaporous atmosphere. Here we are reminded that gravity on the Moon is greatly inferior to gravity on the Earth. On the Moon a six-fold displacement in height or distance would be caused by the same amount of force—that is to say, the same amount of force which would throw a stone a mile high here would on the Moon throw it six miles. Placed in the mathematician's scales, eighty-one and a half Moons would be required to balance the Earth.

In 1792, and for several consecutive years, Schröter perceived a delicately tinted light hovering about the mountain tops which suggested faint twilight. He concluded that the appearance indicated a thin atmosphere about twenty-nine times more tenuous than the Earth's atmosphere. This was rather startling to those who believed in the existence of lunar conditions resembling ours. How could its inhabitants breathe air so fine and live? Confidence, however, was restored when it became known that Schröter had discovered one of the Cities of the Selenites! The revelation was hailed with delight by all true believers in a lunar world like our own. Now lay before them a fair prospect of becoming, if not members, perhaps spectators of a new community of living, intelligent beings, who possibly may be waving signals to attract our attention! No one doubted that the Selenites would have agreeable residences. Indeed, Herr Gruithuisen, of the Munich Observatory, did not despair of being an eye-witness some day of festal processions in the Moon. The uplifted doctor, like Swedenborg, had visions of planetary life, and saw in the phosphorescent gleam ("Künstliches Feuer") occasionally seen in the atmosphere of Venus the reflection of a grand illumination got up by the inhabitants of the planet in celebration of some periodically recurring event! In support of his belief that the Moon had a rich store of the first elements of life he would point to the gray-tinted depressed surfaces lying between latitudes 65 degrees North and 55 degrees South, telling plainly (to eyes responsive to the suggestions of a lively fancy) of several kinds of vegetation which, moreover, preserved in shade and color the correspondence observed on Earth between increasing latitude and elevation. Looked at in this way it is easy to believe that the color of these walled-in plains may be due to some sort of plant-life, though it is difficult to reconcile the thought with the conditions known to be present on the Moon. Prof. W. H. Pickering's lunar observations, however, lend support to the belief that vegetable life may exist on the sloping sides of the small craters, where he noticed changes in minute detail which he thought indicated the presence of vegetation, the product, perhaps, of moisture oozing out of vents in their sides. There were signs plainly visible of volcanic activity. Turning to the crater named Plato, he remarks, "It is, I believe, more active than any area of similar size upon the Earth. There seems to be no evidence of lava, but the white streaks indicate, apparently, something analogous to snow or clouds. There must be a certain escape of gases, presumably steam and carbonic acid, the former of which, probably, aids in the production of the white markings."[2] These cautious remarks may in part have been suggested by the views of earlier observers of the Moon. Sir William Herschel had, in April, 1787, expressed similar opinions respecting volcanic activity in the Moon's crust. Observing our satellite in that month, he says, "I perceived three volcanoes in different places in the dark part of the Moon. Two of them are already nearly extinct, or otherwise in a state of going to break out. The third shows an eruption of fire, or luminous matter." Resuming his observation the following night, he adds, "The volcano burns with greater violence than last night; its diameter cannot be less than three seconds; hence, the shining, or burning matter must be about three miles in diameter. The appearance resembles a *small piece of burning charcoal when it is covered with a very thin coat of white ashes;* and it has a degree of brightness about as strong as that with which a coal would be seen to glow in faint daylight."

Before yielding implicit acceptance to these interpretations, it may be well to consider the difficulties which lie in the way of minute inspection of the lunar surface. They are many and troublesome and such as are peculiarly open to illusion. Its actual conformation, for example, is revealed to the eyes indirectly through irregularities in the distribution of light and darkness. The forms of its elevations and depressions can be inferred only from the shape of the intensely black shadows cast by them; and these shapes are in constant fluctuation, partly through the change in the angle of illumination, partly through changes in our point of view, caused by what is called the Moon's libration. Besides these changing conditions, there are always present air waves or quiverings, even in the purest skies. And, unfortunately, every increase of optical power magnifies, and thereby increases, these atmospheric troubles. Feeble manifestations of interior energy had long been suspected, but they are generally regarded as having no significance other than as the lingering remains of the early convulsions which produced its present rugged surface. It is not improbable that a low stratum of carbonic acid gas or moisture, the frequent product of volcanoes, may flow down the sides of the crater-like formations, but that plant-life must necessarily ensue is at best but conjectural. We are here brought face to face with the old question: Is life in any form a necessary product of inorganic matter, be the combination of elements what they may? All the theories yet advanced to explain the origin of life on this planet, as that of a slow spontaneous generation, are mere fantastic speculations devoid of scientific foundation. Among the more curious of these is the conjecture hazarded by H. E. Richter to the effect that life came to the Earth as cosmic dust in meteors thrown off from other worlds. Toward the end of the nineteenth century Sir W. Thomson (Lord Kelvin) and H. von Helmholtz, independently, raised and discussed the possibility of such an origin of terrestrial life, laying stress on the presence of hydrocarbons in meteor stones.[3] But it does not follow that life-germs, vegetable or animal, should be present in these ejects from far-off stars or neighboring planets; certainly, the chemist has found in them nothing to warrant the assumption. When the insoluble is reached, the idealist, true to the faith within him, reverts to the old doctrine of a special creation, and is at rest. But the materialist turns into another path and resumes his prodding and plodding to the barren end.

The Region from Theophilus to Tycho.

Here the craters are most numerous. It is probable that the total number of craters and craterlets visible upon the moon under favorable conditions exceeds two hundred thousand, but is less than one million.

That the Moon is an exact copy of the Earth, as the early observers had fondly believed, became more and more doubtful with every increase of optical power. The gray spaces thought to be seas, and still so named for convenience, are now seen to be dry open plains. Nor is there much on Earth to compare with the giant circles supposed to be craters of extinct volcanoes, some of them twenty miles in diameter, with lofty peaks towering high above the rings. And if we bear in mind that its month is divided into one day and one night; that there can be no change of seasons there as with us, ushering in the advent of spring when all nature is filled with gladness, nor summer, nor winter, we see how very different lunar conditions are from those of Earth, and how improbable it is that life such as we know of can ever have existed on the Moon.

The discovery which more than any other dissolved the pleasing vision of a lunar world peopled by intelligent beings was that it had no appreciable atmosphere. Sir John Herschel had shown the non-existence of any air on the Moon having 1/1980 part of the density of the Earth's atmosphere at sea-level. And the spectroscope in the hands of Sir William Huggins has shown that light from the Moon does not produce the dark lines due to aqueous vapor. Curiously enough, the most striking evidence of the absence of atmosphere about the Moon comes from the stars. In 1865 it was noticed that the Moon passed over the star ε Piscium without showing any sign either at imersion or emersion of selective absorption; the light of the star went out as suddenly as if a slide had been dropped over it. If an atmosphere had surrounded the Moon the extinction of the star's light would have been gradual, and the same on leaving the star. The instantaneous extinction and sudden flashing out of the light of a star occulted by the Moon is a sight worth sitting up into the small hours of the night to witness. An occultation of Jupiter by the Moon was observed by Prof. W. H. Pickering on the 12th of August, 1892. He noticed a slight flattening of the planet's disk through the effect of lunar refraction in an atmosphere possessing only 1/4000 the density of our atmosphere. And five years later Prof. Comstock, of the Washburn Observatory, using a sixteen-inch Clark equatorial telescope, found that the displacement of occulted stars arising from refraction was so small as to preclude the existence of a permanent lunar atmosphere of more than 1/5000 the density of the Earth's atmosphere. The kinetic theory bears testimony to the same effect. Dr. Stoney has shown that if all the essential elements of an atmosphere—oxygen, nitrogen, and water-vapor—originally existed on the Moon, they would slowly escape into space, because the maximum velocities of their molecules are greater than a mile and a half per second, i. e., than the Moon's gravity could retain. All the occultations of stars by the Moon observed up to the year 1909 have been practically instantaneous.

The best time for getting a good view of its surface is during the first quarter, particularly along the line called the terminator—that which separates the illuminated part of the disk from the dark part. Good eyesight trained to minute observation, even without a telescope, perceives varieties of light and shade; here dusky patches, there points of superior brightness, especially on the eastern and southern quarters. These differences are due to inequalities on its surface. The appearance suggests mountains rising high above the plains which catch the first slanting rays the Sun is shedding upon the Moon. With the aid of the gigantic telescopes now employed, particularly in the United States and at Peru, which in some cases magnify six-thousandfold, these features come prominently into view, and present a scene of wondrous complexity—of weird strangeness, delicate beauty, and imposing grandeur, such as the eye of man never before rested upon. Closer scrutiny brings out the half-suspected truth, and reveals mountain peaks illuminated by the Sun while yet it is dark in the valleys below. The black shadows thrown by these gleaming pinnacles towering upward like the spires of some majestic cathedral are almost startling. At first they are very long, then as the Sun ascends above the horizon the lower parts are gradually swathed in light. There are some cavities in crater-like formations so deep that no ray of sunlight can ever penetrate their depths. When they are so situated that the Sun's light is just beginning to shine into them, a luminous crescent comes into view on the side farthest from the Sun, while a deep black shadow is cast on the opposite side.[4] These shadows clearly indicate that the tops of the "craters" are elevated far above the general level of the ground from which they rise. By glimpsing these shadows we get their altitude. Some of the mountains lie along massive chains suggestive of the Alps, Apennines, or Andes. Others, shaped like a sugar-loaf, rise abruptly from plains nearly level, and present an appearance somewhat like Mount Etna or the Peak of Teneriffe. Their shadows extend in the form of a pyramid half across the plain to the opposite ridges. The highest are in some places more than four miles in perpendicular altitude. A striking feature is the circular-shaped caverns which are to be seen on almost every region of the Moon's surface, but are most numerous in the southwest quarter, where nearly a hundred may be distinguished.

The generally accepted theory that the rugged features which the Moon presents are the product of lunar volcanoes, or of forces acting from within, can hardly be regarded as tenable after a critical examination made with the wonderful optical powers of to-day. Everywhere are seen evidences of the operation of a force acting from without. For example, the isolated ring-mountains, called in all maps of the Moon "craters," present features which do not correspond to craters on Earth. Some are situated in level plains of an oval shape inclosed by a wall of mountains; the dark gray basin called Plato is an instance of this peculiarity; it stands near an immense mountain uplift, named the Lunar Alps. There are mountain-walled circular chasms chartered "craters," which have in the middle of their depressed floors a peak, while their inner and outer walls are seamed with ridges. The cavities sink

[2] The reader who is interested in Prof. Pickering's researches on active volcanoes and vegetation on the moon will find further information on those topics in Prof. Pickering's book "The Moon."—Ed.

[3] See the article "Biology," by Dr. Chalmers Mitchell, in vol. xvi. of the Encyclopædia Britannica, 11th edition.

[4] For a fuller description of lunar scenery, see "Other Worlds," by G. P. Serviss (Hirschfield Bros.).

in some cases as low as four miles below the loftiest points upon their walls. It may be urged, further, that these scars on the Moon's face differ from terrestrial craters in the important particular that while craters on the Earth are hollow on a mountain-top, with a flat bottom high above the level of the surrounding country, those upon the Moon have their lowest points of depression far below the surface of the ground, the external height being only one half, or a third of the interior depth. Our planet offers a noteworthy example of a supposed volcanic crater formation which on close scrutiny has proved to be nothing of the kind. In central Arizona (U. S. A.) there is a crater-like mountain called Coon Butte, which rises to a height of 150 feet above the level of the ground. On the top is a wide circular opening three quarters of a mile in diameter, and 540 feet deep, the bottom of which is about 400 feet below the level of the ground outside. This yawning chasm, the most dreary and desolate that can well be conceived, had always been regarded as the undoubted remains of a once-active volcano. Two men of science undertook a thorough examination of the place; Mr. Barringer (geologist) says, "The evidence of facts do not leave a scintilla of doubt on my mind that this mountain and its 'crater' were produced by the impact of a large meteorite, or small asteroid." Mr. Tilghmann (physicist) feels "justified, under due reserve as to subsequently developed facts, in announcing that the formation of the locality is due to the impact of a meteor of enormous size."

Turning next to Sir George Darwin's inquiry into the origin of the Moon, we learn that in the far-off past—an approximate calculation indicates fifty-four millions of years ago—the Earth was revolving on its axis in a period somewhere between two and four hours; that the most rapid rate of rotation of a fluid mass of the Earth's average density consistent with equilibrium is two hours twenty minutes. Quicken the movement further and the globe must fly asunder. Hence, the inference that, like a grindstone driven at too rapid a rate, a portion broke away. Then gravitational influences arising out of solar tidal friction held the lesser part aloof as a tributary to the parent orb. Tracing by analytical methods the past career of the two bodies, Sir George Darwin arrives at a period when the two bodies were in very close contiguity, one rotating, the other revolving in approximately the same time, and that time certainly not far different from, and quite possibly identical with, the critical moment of severance. Summarizing his investigation, he asks, "Is this a mere coincidence, or does it not rather point to a break-up of the primeval planet into two masses in consequence of a too rapid rotation?" The theory rests upon the sure ground of mathematical demonstration, and is now generally accepted. Though Dr. See contests it, holding the opinion that the Moon reached the Earth from the outside and was captured.

In view of these conditions, namely, the marked difference of the lunar surface formations from volcanic craters on Earth, the Earth's rotating at a rate so swift as to cause the portion forming our satellite to detach itself, it is a reasonable conjecture that we have the origin of the Moon's rugged surface in the lesser portions of Earth-matter which, from the same cause, would be thrown off in the same direction and pierce the side of the Moon turned earthward. During the Moon's plastic period, too, meteors, may have added greatly to the marring of her features.

Thus, with the aid of the mathematician's inward eye, we are able to witness the birth of our Moon, destined in the fulness of time to illuminate our evening skies; to keep the waters of the great deep fresh and sweet by raising tidal waves laving the seashores, and so contributing largely toward making this Earthly dwelling-place of ours the best of all possible worlds.

The United States Indian Census

POPULATION.

The total number of Indians in the United States, exclusive of outlying possessions, in 1910, was 265,683, and in Alaska, 25,331. The corresponding figures for the census of 1900 were: United States, 237,196; Alaska, 29,536; and for the census of 1890, United States, 248,253; Alaska, 25,354.

According to these figures, which cover the last three enumerations only, the number of Indians in the United States decreased between 1890 and 1900 but increased during the last decade, the increase for the 20-year period 1890-1910 being 17,430, or 7 per cent. The data from the reports of the Commissioner of Indian Affairs, which are given in the bulletin, indicate that the number of Indians decreased from 1870 to 1890 and increased by about the same amount in the following 20 years. In Alaska the number of Indians reported decreased from 1880 to 1910 by 7,665, or 23.2 per cent. The figure for 1890 is probably incomplete, owing to the unexplored condition of the country at the time, so that the increase between 1890 and 1900 may be only apparent. The figure for 1880, though based in part on an estimate, is believed to be approximately correct. It is probable that the census returns for 1910 and 1900 are fairly comparable, but the difficulties of enumerating the Alaska Indians are so great that conclusions from the statistics must necessarily be tentative.

The number of Indian tribes reported for the United States in 1910 was 280, comprising 53 linguistic stocks. Of these tribes, 77 had more than 500 members each, while 42 were represented by 10 members or less; of the latter, 10 were represented by 1 member each. The most important tribes numerically were the Cherokee, with 31,489 members; the Navajo, with 22,455; the Chippewa, with 20,214; the Choctaw, with 15,917; and the Teton Sioux, with 14,284. These 5 tribes comprise all those represented by over 10,000 members; 39 other tribes had over 1,000 members each.

In Alaska 66 Indian tribes, forming 7 linguistic stocks, were reported. The principal ones, aside from the Southern Eskimau group, were the Kuskwogmiut, the largest tribe of the Eskimauan linguistic group, with 1,480 members, and the Aleut, with 1,451; 11 other tribes were represented by more than 500 members each.

Oklahoma had by far the greatest number of Indians reported for any State in 1910, 74,825, or more than one fourth of all the Indians in the United States, while 7 other States reported more than 10,000 Indians each. These 8 States, all of which, except Wisconsin, are situated west of the Mississippi, contained together nearly three fourths (72.2 per cent) of the total number. Of the Eastern States, North Carolina, with 7,851, and New York, with 6,046, had the largest Indian population. While there were Indians in every State of the Union in 1910, the number in some was extremely small, 4 States—Delaware, Vermont, New Hampshire, and West Virginia—having less than 50 Indians each.

The proportion of Indians in the United States declined steadily from 1870, when it was 72.1 per 10,000 of the total population, to 1910, when it was 28.9. In Alaska the decline in the proportion of Indians has been even more pronounced, the number in each 10,000 of the total population decreasing from 9,871.4 in 1880 to 3,936.1 in 1910. Thus, while in 1880 almost the entire population of Alaska consisted of Indians, in 1910 they formed only about two fifths of all the inhabitants.

BLOOD.

The Thirteenth Census was the first at which any returns worthy of tabulation were secured as to the proportion of full-bloods and mixed bloods in the Indian population.

Of all the Indians in the United States in 1910 56.5 per cent were full-bloods and 35.2 per cent mixed bloods, while for 8.4 per cent information on this point was not given.

Of the 93,423 Indians reported as mixed bloods, 88,030, or considerably more than nine tenths, represented a mixture of white and Indian, 2,255, of negro and Indian, and 1,793, of white, negro, and Indian, while 80 represented other mixtures, and for 1,265 the kind of mixture was not reported.

In Alaska, 84.7 per cent of the Indians were of full-blood and 15.3 per cent of mixed blood; almost all the mixed bloods were a mixture of white and Indian, the remaining few representing a mixture of Indian with Chinese and Japanese blood.

Twenty and six tenths per cent, or 18,169 of the 88,030 persons of mixed white and Indian blood in the United States were more than half Indian; 24,353, or 27.7 per cent, half Indian and half white; and 43,937, or 49.9 per cent—practically one half of the total—were more than half white. Thus about four fifths of the Indian and white mixed bloods were at least half white.

The number of negro and Indian mixed bloods reported, 2,255, is probably an understatement, owing to disinclination to admit negro blood. Of the number reported, 31.8 per cent were more than half Indian, 32.3 per cent half Indian and half negro, and 34.6 per cent more than half negro, while for 1.3 per cent the proportion of negro blood was not reported.

In each of five adjoining States—New Mexico, Utah, Arizona, Colorado, and Nevada—which comprise a large part of the interior arid plateau, the proportion of full-bloods among the Indians exceeded 85 per cent. Iowa and Mississippi, where the Sauk and Fox and the Choctaw tribes, respectively, have preserved a high degree of purity, were the only other States with at least 100 Indians in which more than 85 per cent of the Indians were full-bloods.

The proportion of full-bloods was frequently higher in the States with a large Indian population; a notable exception is Oklahoma, which has by far the largest number of Indians, but reported a small proportion of full-bloods, 36.6 per cent. This low proportion in Oklahoma is no doubt due in part to the fact that the possession of valuable lands by the Indians encourages intermarriages between whites and Indians, and that persons with very little Indian blood are anxious to establish their claims as members of the Indian tribes, in order that they may be entitled to participate in the distribution of lands and moneys belonging to the Five Civilized Tribes in Oklahoma.

SEX.

Of the 265,683 Indians reported in the United States in 1910, 135,133, or 50.9 per cent, were males, and 130,550, or 49.1 per cent, females. The number of males to 100 females was 103.5. In Alaska the number of males in 1910 was 12,995 and of females 12,336, the ratio of males to 100 females being 105.3.

In 1910 the ratio of males to females among the Indians (103.5 to 100) was not as great as in the total population of the United States (106). Among the native whites of native parentage the number of males to 100 females was 104, and among the foreign-born whites 129.2, but among the negroes only 98.9.

In the United States, according to the returns, the number of males to 100 females was considerably less (101.7) among full-blood Indians than among those of mixed blood (106.4). This condition is reversed in Alaska, where the proportion of males to 100 females was 106.2 among full-bloods and 100.3 among mixed bloods. As the number of mixed bloods in Alaska was comparatively small, however, no reliable conclusions can be based on the sex distribution among them.

The greater preponderance of males shown among the mixed bloods than among the full-bloods in the United States is probably due in part to the tendency to report as white Indian women of mixed blood who are married to white men.

The figures apparently indicate that the excess of males decreases with the increase in the amount of white blood, but since the division by degree of mixture is only approximately accurate no reliable conclusion can be drawn from these proportions.

AGE.

Over one half (51.5 per cent) of the Indians in the United States in 1910 were under 20 years of age, over one third (36.1 per cent) from 20 to 50 years, and about one eighth (12 per cent) 51 years and over. In 1900 the proportion of young and old persons was slightly less and that of persons of the intervening age group slightly greater than in 1910. In Alaska in 1910 the proportion of young and old persons was smaller and that of persons in the intermediate age period considerably greater than in the United States.

The fact that stands out most prominently is the high proportion of young persons among the mixed bloods as compared with the full-bloods. A similar difference is to be noted between the mixed tribal bloods and the full tribal bloods. In both cases the difference may be accounted for in part by the fact that mixed marriages had not become common until within comparatively recent years. Another reason for the predominance of the young element among the mixed bloods is no doubt found in the greater fertility of mixed marriages.

FECUNDITY AND VITALITY.

Information was collected by the Census Bureau in 1910 in regard to the number of children born by every married woman. Only those women were included who were between 15 and 44 years of age, who had been married for at least one year, and who were neither widowed nor divorced nor married for a second or subsequent time.

The most significant fact is that, while for all classes of marriages the proportion resulting in no issue was 8.6 per cent, for marriages between full-bloods the proportion was 10.7 per cent, and for mixed marriages it was 6.7 per cent. Thus sterility is considerably less common in cases of miscegenation than in cases of marriage between full-bloods. Furthermore, the proportion of issueless marriages decreases directly as the amount of white blood in the married couple increases. Thus an inverse relation between the amount of white blood in the married couple and the proportion of childless unions seems to be established.

A comparison of the figures for marriages between full-bloods with those for mixed marriages shows the greater fertility of the latter; a smaller proportion resulted in two children or less and in from three to five children than in the case of the pure marriages and a much higher proportion in six or more children. A larger proportion of the children having one white parent survive than of children both of whose parents are full-blood or mixed blood Indians, but do not in themselves show whether this is due to conditions in the home or to greater virility of the offspring.

The results of the studies on sterility, on fecundity, and on vitality all indicate that the increase of the mixed blood Indians is much greater than that of the full-blood Indians, and that unless the tendencies now at work undergo a decided change the full-bloods are destined to form a decreasing proportion of the total Indian population and ultimately to disappear altogether.

Evolution from the Standpoint of Physics—III*

The Principle of the Persistence of Stable Forms

By Alfred J. Lotka, M.A., D.Sc.

Concluded from Scientific American Supplement, No. 1953, Page 354, June 7, 1913

One of the most important phases of the theory of evolution is its application to the problem of the origin and development of biological species.

We shall obtain a quantitative view of the relations here involved, if we develop somewhat more in detail the concept of evolution as a redistribution of matter, as outlined on page 346.

In considering a system comprising a number of species $S_1 S_2 \ . \ . \ . \ S_n$, consisting severally of $N_1 N_2 \ . \ . \ . \ N_n$ individuals, the distribution of matter in the system may be defined by stating:

1, the values of $N_1 N_2 \ . \ . \ . \ N_n$;

2, the values of certain coefficients $C_1 C_2 \ . \ . \ . \ C_n$ defined as follows:

Let $C_1 (t, p, q, r \ . \ . \ .) = C(\omega)$ be such a coefficient relating to the species S_1, that out of the total N_1 of individuals, the number $(dN_1)_\omega$ comprised within an infinitesimal element ω, i. e., all those for whom certain characteristics $P, Q, R \ . \ . \ .$ have at time t values lying between the infinitesimal limits

$$p \text{ and } p+dp$$
$$q \text{ and } q+dq$$
$$r \text{ and } r+dr$$

is given by

$$(dN_1)_\omega = N_1 C_1(t, p, q, r \ . \ . \ .) \, dp \, dq \, dr \ . \ . \ .$$
$$= N_1 C_1(\omega) \, d\omega$$

Let $C_2, C_3, \ . \ . \ . \ C_n$ be coefficients similarly defined with relation to the species $S_2 S_3 \ . \ . \ . \ S_n$.

The evolution (that is to say the change in the distribution of matter) in the system then appears as the result of two components:

1. Changes in $N_1 N_2 \ . \ . \ . \ N_n$;
2. Changes in $C_1 C_2 \ . \ . \ . \ C_n$.

In other words, the matter of which the system is composed undergoes a change in its distribution:

1. among the several species,
2. among the several types of individuals of which each species is composed.

We may accordingly distinguish an "inter-species" evolution and an "intra-species" evolution.

If, instead of considering the system as a whole, we center our attention on some one individual species, it may be said of this in particular that in general it will change:

1. in extent,
2. in character (constitution),

as time goes on. And in particular, it may so happen that after the lapse of a sufficient period of time, the latter change, change in character, becomes so fundamental, that we see in the resulting material a new species.[16]

The point of view developed above furnishes the basis for a mathematical treatment of the subject. We shall not follow up this point any further. At the same time it shows the way for the attack of the last phase of the problem of evolution which shall now be briefly considered: The energetics of organic evolution.

If we survey the transformations of energy which accompany the evolution of a material system, we note, first of all, that they may be classified under three heads:

In the first place, every change in the distribution of matter among the components of the system is in general attended by a definite energy-change. Thus, for example, every physical or chemical change of state has a certain definite "latent" heat.

Secondly, in a system which receives a steady supply of energy from outside (such as for instance our earth and its living population, fed with radiant energy from the sun), definite energy changes attend not only any changes which may occur in the distribution of matter in the system, but such energy changes are also bound up with the more continued existence (e. g., in a steady state) of certain forms.

Thirdly, inasmuch as the totality of the energy changes required to maintain the several components of such a system as we have just been considering, depends on the amount of its several components—i. e., on the distribution of matter in the system—it follows that every change in this distribution brings with it not only energy changes of the first type, the "latent heat" type, but also a secondary influence upon energy changes of the second type mentioned in the preceding paragraph.

As regards the energy changes of the first type, we shall merely remark in passing that in the case of organic evolution they probably play only a subordinate rôle, while those of the second and third type rise to particular importance. This is just the opposite of the state of affairs which prevails in most cases of change of state known to us in physics and physical chemistry.[17]

As regards the energy changes of the second and third type, the following treatment, based on Helm's discussion of collective forms of energy,[18] suggests itself:

Consider any system X which we may regard as divided up into two parts, A and B. In its interactions with B let A (in a small interval of time dt, say) receive by direct energy transfer

a quantity q_{a_1} of an energy e_a at the intensity i_{a_1}
" " q_{a_2} " " " e_a " " " i_{a_2}
. . . .
a quantity q_{b_1} of an energy e_b at the intensity i_{b_1}
" " q_{b_2} " " " e_b " " " i_{b_2}
. . . .
etc.

The portion B of the system will then receive at the same time

a quantity q'_{a_1} of the energy e_a at an intensity i'_{a_1}
" " q'_{a_2} " " " e_a " " " i'_{a_2}
. . . .
a quantity q'_{b_1} of the energy e_b at an intensity i'_{b_1}
" " q'_{b_2} " " " e_b " " " i'_{b_2}
. . . .
etc.

Now for each individual energy transfer we have the relation:

$$\frac{q'}{i'} \geqq -\frac{q}{i} \qquad (4)^*$$

or

$$\frac{q'}{i'} + \frac{q}{i} \geqq 0 \qquad (5)$$

and hence for the totality of all the energy transfers in the system:

$$\sum \left(\frac{q'}{i'} + \frac{q}{i} \right) \geqq 0 \qquad (6)$$

or, if we simply include the terms $\frac{q'}{i'}$ in the summation $\sum \frac{q}{i}$, then we may write simply:

$$\sum \frac{q}{i} \geqq 0 \qquad (7)$$

Now it may lie in the nature of the system A, that there is a definite relation between the quantities $q_{a_1} \ q_{a_2} \ldots, q_{b_1} \ q_{b_2} \ldots$, etc. In particular, if we put

$$\Sigma q = Q \qquad (8)$$

and

$$\sum \frac{q}{i} = \frac{Q}{I}, \qquad (9)$$

this relation may assume the form:

$$\left.\begin{array}{l} q_{a_1} = f_1(i_{a_1}, I)Q \\ q_{a_2} = f_2(i_{a_2}, I)Q \\ \ldots \\ q_{b_1} = f'_1(i_{b_1}, I)Q \\ q_{b_2} = f'_2(i_{b_2}, I)Q \\ \ldots \end{array}\right\} \qquad (10)$$

etc.

In such a case we may say that the functions f define the character, or better the "constitution" of a "composite energy" E, whose intensity factor is defined by I, and whose capacity factor is $\frac{Q}{I}$. This latter, by the way, is, other things being equal, proportional to the total mass of A.

From equation (6), which we may now write,

$$\frac{Q'}{I'} + \frac{Q}{I} \geqq 0 \qquad (11)$$

we see that this capacity factor increases or, in the limiting case, remains constant in every transfer of the energy E. In other words, it follows a generalized law of increase of entropy.

Applying this to a species of organisms, we note first of all that under given conditions a species of given constitution has a definite mode of reaction upon its environment, determined by that constitution. In other words, it has a definite "composite energy," which, according to what was said above, follows a generalized law of increase of entropy in all the reactions of the species with its environment.[19] In the course of the evolution of a system comprising a number of species, there will take place, on the one hand, changes in the capacity factors of the several specific (and also other) energies, owing to inter-species evolution; and on the other hand, owing to intra-species evolution, each specific energy will in general undergo changes in character, in "constitution," corresponding to the changes in the constitution of the species. For there is a definite relation between the constitution of each species and that of the corresponding specific energy.

We thus arrive at the observation that, side by side with the evolution of matter, and parallel with it, there proceeds an evolution of the composite energies.[20] In either case it will be convenient to distinguish between inter-species and intra-species evolution. The investigation of the laws governing such evolution is a problem in energetics. Here also it would appear that a generalized law of increase of entropy must apply. For if it applies to each step of a series of interactions, the conclusion seems warranted that it must apply also to the series as a whole. Moreover, in the case of heat energy in particular, it is well known that the law of increase of entropy applies not only to the transference of heat from one body to another by conduction, but also to those internal readjustments which take place in the distribution of the velocities of the molecules of a gas during the "relaxation period," and which represent a change in the constitution of the energy of the gas, thus corresponding to intra-species evolution.

In point of fact Winiarski[21] in his "Essai sur la mécanique sociale" suggests the application of the entropy principle[22] to social systems. But in Winiarski's treatment the intensities are not energy factors directly, but "desires," which in turn are to be measured indirectly in terms of prices. That there should be a parallelism between desires and certain energy intensity factors is only to be expected, inasmuch as such desires appear as essential factors in the functioning of our adjustors, and if these adjustors are to work effectively, such parallelism must exist. But our adjustors are not perfect, and in consequence the parallelism also is imperfect.[23] In other words, while, in general, the desires of the individual tend for the stability or preservation of the species, this is not by any means invariably the case. If an example is desired we need only point to the habitual drunkard, the morphine fiend, the gambler, and so forth.[24] We have here a problem which requires further analysis.

With this provisional plan of attack of the energetics of evolution we will close our present considerations. The further elaboration of the physics of evolution must be carried out with the aid of mathematical methods. And in dealing with the problem it will no doubt be found convenient to follow the arrangement outlined above (p. 354), and to consider first the changes of matter, or in other words the mass relations involved. After this point has been cleared[25] we shall be prepared to proceed to the investigation of the energy relations involved.

* Translated and revised for the Scientific American Supplement by the author from the *Annalen der Naturphilosophie.*

[16] In case that a new species arises as the result of mutation, an extended lapse of time is not necessarily required for the process.

[17] Photochemical reactions, however, approach the conditions which are characteristic for organic evolution.

[18] Physikalische Zeitschrift, 1907, 8 p. 836; Annalen der Naturphilosophie, 1907, vi., p. 366.

*** This follows, for example, from the considerations developed in Helm's "Lehre von der Energie," 1887, p. 65.**

[19] It should be remarked that in applying this law of increase of entropy care must be taken to include the whole of the system in interaction. In the case here considered, therefore, the sun must be included in the system.

[20] In his "Vorlesungen über Naturphilosophie," p. 291, Ostwald discusses the number of possible forms of energy. In the composite energies it would seem that we had an unlimited class of possible forms of energy.

[21] Revue Philosophique, 1898, 45 p. 351; 1900, 49 pp. 113, 256.

[22] W. D. Bancroft has sketched an application of the principle of Le Chatelier and van't Hoff to biological systems. This principle is a qualitative deduction from the quantitative relation embodied in the second law, so that this mode of treatment and the one here presented have something in common. See Bancroft, Jl. Am. Chem. Soc., 1911, p. 91; P. Ehrenfest, Zeitschr. physik. Chem., 77, p. 227.

[23] Compare Herbert Spencer, Principles of Psychology, section 124; The Data of Ethics, section 34.

[24] Among animals also very inappropriate reactions (and therefore desires) are commonly observed. Compare M. Maeterlinck; La vie des abeilles, 1901, p. 106; and also Prof. Loeb's work, The Mechanistic Conception of Life. The relation of desires to stability (preservation of the species) is also clearly brought out in phenomena of social dynamics. It might be supposed that a maximum of stability would be reached in a given community, when all disputed questions were settled according to the vote of the majority. But this supposition implies that the desires of the majority are always the most judicious—a supposition which is unwarranted, even though with the progress of time we are, through the diffusion of education, etc., continually approaching this ideal.

[25] This plan has since been carried out by the author. See Physical Review, 1912, p. 235.


The Eel-pout.


The Common Sculpin.

Ugly Fishes*

Freaks of Nature in Marine Life

THE charm of beauty has been sung by poet and discussed by philosopher from time immemorial, but the fascination of ugliness has been almost wholly neglected. Beauty of form, of motion, of color in all nature have been extolled as though there were in reality more of nature in the presence of these qualities than in their absence.

Considering this attitude of the human mind toward that which it holds to be praiseworthy in nature, it is not strange that much has been written concerning the fine colors, the grace of motion or the symmetry of form of many or even of most fishes, since most fishes do possess one or all of these qualities to some noticeable degree. Now while there cannot be the slightest objection to lauding the beautiful, I maintain that the few fishes which do happen to be lacking in this respect should not go unmentioned on that account. For while symmetry, grace and pleasing colors undoubtedly may make a fish attractive, yet even in the absence of these qualities it is possible for a fish to be attractive by reason of positive ugliness. I say *positive* ugliness, for ugliness such as is possessed by the fishes mentioned in this article is not to be classed with mere absence of beauty. Like the ugly man in the story, these fishes are "professionals" and have a deep-seated, ingrowing ugliness that gives them a fascination all their own.

Of course there are all degrees of fishy ugliness, and the fascination for the beholder which some unbeautiful fishes possess, comes often from some unfishlike quality rather than from pure ugliness. Take as an example the big green moray. It is hardly a beautiful fish, at least to the eyes of the layman, but people will crowd around the moray tank to enjoy the sensation of a good spine-thrilling shudder, and not because the moray is ugly, but because, forsooth, he looks somewhat like a snake! Or, take the seahorse. While I would not for a moment suggest that the seahorse, adopted as the ensign of the Aquarium, is ugly, still he possesses as little beauty, as that term is understood among fishes, as one could desire. He is a most interesting and attractive little creature—because of features that are not fish-like. The only things about him that seem to shows a relation to ordinary fishes are his fins, and they usually vibrate so rapidly that they cannot be seen. The visitors at the Aquarium will stand three or four deep around the seahorse tanks and admire him for what he appears not to be.

To introduce at once the highest degree of ugliness might prove too much of a shock to the mind of the reader, who, presumably, is accustomed only to the consideration of beauty. Therefore, we will begin with the puffer or swellfish. The engraving below will bear out the statement that, as far as form is concerned, he is no beauty, and only a casual glance at the movements of a specimen in the tank will reveal the fact that he is anything but graceful. His colors are well enough except that he has green eyes which might indicate a consuming jealousy. His disposition is ugly too, and his sharp teeth, like a pair of nippers, are well fitted for biting off the tails and fins of his neighbors or for taking a piece out of the unwary finger. Yet the puffer is not without his interesting points. His habit of inflating himself into a ball by means of either air or water, which is retained by a valve in the throat is one of the curiosities of nature. Mitchill mentions that "it is a piece of sport common enough among fishermen to burst them between two stones, when the air is let loose with a noise almost equal to the report of a pistol." While this may be entertaining to the fishermen, it is rather hard on the fish, and it is not to be encouraged. The puffer is ugly and interesting in about equal proportions.


Toadfish (Ventral View).
He looks like a wide-mouthed tadpole.

The toadfish, flat-headed and big-bellied and looking more like a wide-mouthed tadpole than a fish, is interesting to the naturalist from many points of view, but he is certainly not pretty. The fishermen are not friendly toward him, for he is a voracious feeder and his appetite is wholly incommensurate with his size. For this reason he makes away with the bait intended for some larger fish and when he is hooked he is good for nothing. But the visitor at the Aquarium always looks twice at the queer little fish with the bull-dog jaws, which appears to be, and in reality is, the personification of piscine impudence.

The eel-pout, also known as the muttonfish, possesses several important points of ugliness, as the figure shows. But it is a useful fish and perhaps for that reason its appearance should be excused. It reaches a length of about three feet and has considerable importance as a food fish.

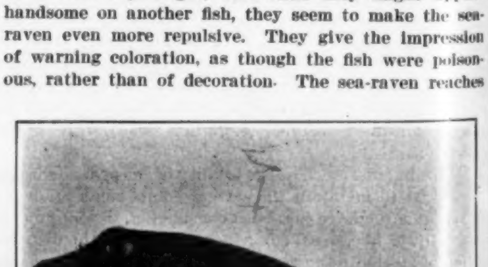
The gurnards or sea-robins are often gorgeously colored, a fact which has led some writers to refer to them as handsome fishes. It is evident, however, that such persons could have looked no farther than the colors or they would have hesitated to apply such a term to any fish with a head like a sea-robin's. It looks very much as though nature, realizing that she had made a mistake in giving the sea-robin such a head, had tried to even things up by adding the bright colors. Any one can see at a glance that it is only a compromise.

The sculpin is rather handsomely barred with black and greenish, but no one would be misled on that account into calling him a beautiful fish. In the words of DeKay, "When freshly taken from the water and irritated they do present rather a formidable appearance. The head is swollen to twice its usual size by the distension of the branchial membranes; the spines stand out prominently, and the rays of all the fins become erect."

Compared with its relative the sea-raven, however, the sculpin becomes quite a normal appearing fish, for the sea-raven looks as though he were designed for the express purpose of frightening naughty water babies into decent behavior. The head, which appears to have been originally intended for a much larger fish, is covered with protuberances, ridges and ragged flaps of skin, the bulging eyes are set high upon the top of the head, and the lower jaw is undershot like that of a prize bull-dog. The colors, which are quite variable, are often very bright, but while they might appear handsome on another fish, they seem to make the sea-raven even more repulsive. They give the impression of warning coloration, as though the fish were poisonous, rather than of decoration. The sea-raven reaches

* Reproduced from its *Bulletin*, Aquarium Number, by special permission of the New York Zoological Society.


The Sea-Raven.
In his natural swimming attitude.

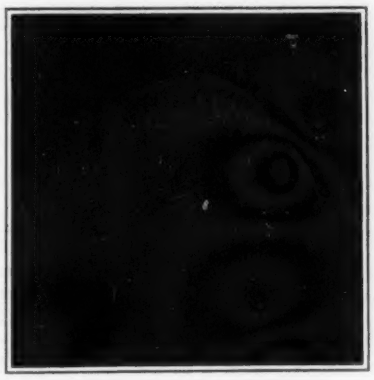

The Common Puffer.
A green-eyed fish of ugly appearance and temper.

a length of about two feet and a large specimen is indeed a fearsome object to behold.

But the palm for ugliness, if in this case such an award is permissible, must unquestionably go to the angler or goosefish. He is the quintessence, the superlative degree of all that is forbidding and abhorrent in the fish world. Dr. Bean passes him by with the remark that he is "a fish of singular ugliness of appearance," but this expression is far too mild. He is a piscatorial nightmare, whose every aspect is repulsive, and if he possesses any redeeming feature whatsoever, it has thus far escaped notice.

Besides the names given above, he is known as the bellows-fish, fishing frog, monk-fish, devil-fish, headfish, all-mouth and satchel-mouth, and the application of most of these terms is evident. At the first glance the goosefish seems to be all head, but this is a mistake, for his stomach is astonishingly capacious. When he opens his mouth it looks as if the whole upper half of the fish were coming loose, but there is pace enough left somewhere to contain an enormous quantity of the various fishes which make up his bill of fare. Where he keeps it all is a mystery. The head and the ridiculously small body are covered with ragged fringes of skin which make him look as if he were in the last stages of dissolution and this impression is heightened by the flabby softness of the flesh. The head and the anterior part of the body are flattened out as though he were trying to escape observation by squeezing himself into the sea floor. And such is really the case, but for reasons of domestic economy and not from any special modesty on his part. He is a firm believer in the proverb that all things come to him who waits, so he lies in patient obscurity dangling his tempting lure, until some unwary fish is attracted by it and swims above him. Then with one mighty spasm the whole seabottom in his vicinity seem to rise to engulf the unlucky prey, which is held fast by an array of horrid backward-pointing teeth. The success of this standpat policy is sometimes his undoing, for fishermen are said to open him up to obtain the numerous fishes contained in the stomach of this rapacious and insatiable representative of the finny tribe.

The angler reaches unlimited capacity and a length of about four feet. But though this fish is repulsive in every point of person and character, it must not be supposed that he does not attract attention when on exhibition. Quite the contrary—which brings us back to our original proposition that there is a great fascination in pure unadulterated ugliness.



Jaw of the Angler.

The powerful teeth project backward to hold the prey.

Common Toadfish.

He is as impudent as he is worthless.

The Angler.

One of the lures is seen projecting upward, the others is laid back in the resting position on the top of the head. This specimen was about three feet long.

The Electric Furnace in the Production of Iron from Ore*

A Critical Discussion and a Comparison of Scandinavian and Californian Practices

By D. A. Lyon

As is well known, the electric furnace, under favorable circumstances, may be used in the iron and steel industry for the production of metal from the ore, and later for the refining of this same metal into the grade of steel desired.

CONDITIONS FAVORABLE TO THE USE OF THE ELECTRIC REDUCTION FURNACE.

It was pointed out by the Canadian Commission in their report of 1904, that the prime pre-requisite for the use of the electric furnace in the reduction of iron ores, is cheap electric power. The large amount of experimental and practical work which has been done since that time has only emphasized this fact. The electric furnace, therefore, has not been developed as a competitor of the blast furnace, but, as is the case in Norway and Sweden, for the purpose of keeping alive an industry which finds itself confronted by conditions unfavorable to a continuation of blast furnace practice, due to the increased cost of charcoal; or for the purpose of making possible the development of the iron industry, as is the case in California, where the iron industry has never been developed, due to the cost in that section of the country of both charcoal and coke.

In each country, considerable experimental work was first done and then the furnace was tried out on a commercial scale. As was to be expected, the problems which presented themselves at the outset of the work were not solved at once, and there are still problems which are awaiting a more satisfactory solution than has so far been attained, but satisfactory progress is being made in this direction. That the electric iron ore reduction furnace has entirely passed the experimental stage is evidenced by the situation in California and Scandinavia.

THE SCANDINAVIAN PRACTICE.

As a result of the successful operation of the furnace at Trollhättan, three other iron electric reduction furnaces are now being operated in Sweden which together with the furnace at Trollhättan represent a total of 12,000 horse-power that is being used for electric reduction furnace work in that country; in Norway there is one 3,500 horse-power furnace in operation and one 3,500 horsepower and three 3,000 horse-power furnaces in the course of construction, while in Switzerland one of 2,500 horsepower is being built.

The Uddeholms Company, at Hagfors, Sweden, is increasing its electric furnace installation by the addition of three more furnaces and will probably substitute electric smelting altogether for its blast furnace work. It is also a significant fact that the plant at Trollhättan, which was built by the Jern-Kontoret, of Sweden, purely for the purpose of determining the feasibility of attempting to reduce iron ores in an electric furnace, has been sold by the Jern-Kontoret to the Degerfors Iron Company, and will be worked by the latter company as a commercial proposition from now on. The Degerfors Company is an old-established company, who make very high-grade material, and so it is not a case of a new concern taking up with a new venture, but one with long experience in the business, who has had ample opportunity to carefully study the feasibility of electric reduction furnace work under the conditions prevalent in Sweden, and who, as a result of its study, have satisfied itself that the electric furnace will meet its requirements. In fact, the old saying, "the proof of the pudding is the eating thereof," would seem to apply as regards the use of the electric reduction furnace in Sweden.

SOME OF THE DIFFICULTIES THAT HAD TO BE SOLVED.

If a study be made of the drawings of those furnaces which have been tried out experimentally, it will be noted that in most of them an attempt was made to construct a furnace somewhat similar to a blast furnace, and to introduce the electrodes into the stack of this furnace at that point where the tuyeres are located in the former. All those who tried this soon learned that it was practically next to impossible to maintain the furnace walls adjacent to the electrodes. There was thus evolved as a matter of necessity the type of furnace construction which was finally adopted by the Swedish experimenters and such as is shown in Fig. 1. By referring to the same it will be noted that the furnace consists of two separate parts, namely, the crucible or hearth, superimposed above which is a shaft or stack. One of the most serious difficulties that had to be overcome in the perfecting of the electric reduction furnace was the maintenance of the crucible walls and roof. Such a construction as shown in Fig. 1 solved the difficulty as it meets the necessary pre-requisites, namely, keeping the end of the electrode dipping into the charge, as far removed from the side wall as possible, and second, keeping that part of the crucible out of contact with the charge at the point where the electrode enters the crucible. The reason for having to observe these precautions is due to the fact that the heat is excessive at that point where the electrode comes in contact with the charge, and hence this point should be as far removed as possible from both the side walls and roof of the crucible, in order to prevent the destruction of the same through fusion.

THE ELECTRODE PROBLEM.

When the demand was first made upon the manufacturers of electrodes for large electrodes of, say, 20 inches in cross section and 72 inches long, they experienced considerable difficulty in furnishing an electrode which would not go to pieces when put into commission. This caused considerable loss and annoyance to those attempting electric reduction and steel furnace work. Even if the electrode did not go to pieces, as soon as one half to two thirds of the same had been consumed it became too short for further use, and those unused portions represented a considerable item of expense. At the present time it is not only possible to obtain quite satisfactory electrodes, but also to avoid the waste above mentioned. This is done by joining a new electrode to the butt end of

*Reproduced from *Metallurgical and Chemical Engineering*.

an old one, as is done at Trollhättan and at various other places.

So far our remarks have been applicable alike to the California practice and to the Scandinavian practice. It will, however, at this point, be necessary to discuss each practice separately, as they are at the present time radically different from each other. In order to understand the situation more clearly, it may perhaps be well to briefly outline the development of the electric reduction furnace as it has taken place in California.

THE DEVELOPMENT OF THE ELECTRIC REDUCTION FURNACE IN CALIFORNIA.

For twenty-five years or more a company known as the Shasta Iron Company has owned a deposit of magnetite, located about seven miles from the mouth of the Pitt River, in Shasta county, California. This ore is a very pure magnetite, having on an average the following percentage composition:

Fe	69.90
(Fe_3O_4 89.4; Fe_2O_3 7.3)	
MgO	0.10
MnO	0.18
SiO_2	2.40
P	0.011
S	0.009

Although at one time or another the Shasta Iron Company has planned to make pig iron from this ore, nothing definite was done in regard to the same until the summer of 1906. At this time the possibility of smelting this ore by electricity was brought to the attention of Mr. H. H. Noble, president of the Northern California Power Company. In view of Dr. Heroult's connection with the experimental work which had been done at Saulte Ste. Marie, he was commissioned to construct a plant for the purpose of treating the ores above mentioned. The place selected was at a point on Pitt River, near the mines. This place was named Heroult and is still known by that name.

In July, 1907, the first furnace having been completed, experimental work was begun. This furnace was a 1,500-kilowatt, three-phase furnace of the resistance type. It was soon found that the type of furnace first used presented mechanical difficulties which made its commercial use impracticable, and so it was closed down. A sketch of this furnace is shown in Fig. 2. In construction the crucible resembled a long, ellipitical-shaped iron box. The bottom was made of heavy cast-iron plates, into which had been cast cast-iron lugs or pins, and upon the iron plates was tamped a carbon bottom made of carbon paste. The bottom plates were connected with the bus bars in such a manner as to form a neutral in the three-phase system.

The electrodes passed through the roof, as shown in the sketch. They were suspended from copper holders which were water-jacketed. The charge was fed into the crucible through the pipe *B*, and the gases from the crucibles passed up around *B* into *A*, the idea being to thus preheat the charge in *B* by burning the gases around *B*, air being admitted for that purpose through slots in the outer pipe just above the roof of the crucible. These pipes, however, proved too small, and the charge in them became so hot as to hang, and so they had to be done away with. It was also found impossible to maintain a roof over the crucible, and so the furnace was finally operated as an open-top furnace. Several tons of A No. 1 foundry iron were made in this furnace, and later it was used for making ferrosilicon, but was finally closed down and removed in order to make room for the type of furnace subsequently adopted. After the closing down of this furnace, experimental work was conducted in a 160-kilowatt single-phase furnace, and from the results obtained in this furnace and its methods of operation a 1,500-kilowatt, three-phase furnace was designed and built. This furnace was practically the same in construction as is the furnace shown in Fig. 1. In other words, there was developed simultaneously in Sweden and in California a similar type of furnace, although neither the Swedish inventors nor those engaged in the work in California knew of the other's work. The development of this type of furnace was continued until the spring of 1911. At that time, acting upon the advice of the consulting engineer then in the employ of the Noble Electric Steel Company, a radically different type of furnace was constructed. The object aimed at in the new design of furnace was to secure one which would be as easily controlled, so far as the regulation of the nature of the charge was concerned, as is the present open-hearth steel furnace. This furnace was not a success.

Another type was then hit upon, and this type has since been developed into a commercially successful furnace.

ELECTRIC IRON REDUCTION FURNACE IN CALIFORNIA.

The following information in regard to this furnace and its operation has been furnished the writer by the secretary of the Noble Electric Steel Company, and is chiefly taken from a recent article by R. W. Van Norden on "Electric Iron Smelting at Heroult, Cal." [1]

[1] Reprint from *Journal of Electricity, Power and Gas*, November 23rd, 1912.

The furnace is housed in a heavy steel frame building, covered with corrugated-galvanized iron. It is rectangular in shape, 120 feet long and 75 feet wide, and has a height of about 60 feet. The building is in two sections or bays divided by a line of columns. The more southerly of these is the pouring floor, on which the pigs are cast. Throughout this bay is operated a 50-foot Northern Engineering Company traveling crane. This is electrically operated and has two hoists, one of 20 and the other of 5-ton capacity. A Cleveland Electric Controller & Manufacturing Company lifting magnet, having a capacity of 2,000 pounds, is used in picking up the pigs. This magnet will lift about 1,000 pounds of hot pigs.

The bay to the north of the center columns is given to the electric furnaces, their transformers and the necessary control. While but one furnace having a capacity of 18 tons of pig iron per twenty-four hours is at present in use, two more of slightly greater capacity are practically completed. There is space reserved, and it is intended to immediately construct three more, thus bringing the total number of furnaces in this building to six.

THE FURNACE.

The crucible is contained in a steel shell 27 feet long, 13 feet wide and 12 feet high. The shell is so lined with refractories that the upper half of the box is rectangular, but in the lower half the sides taper toward the center

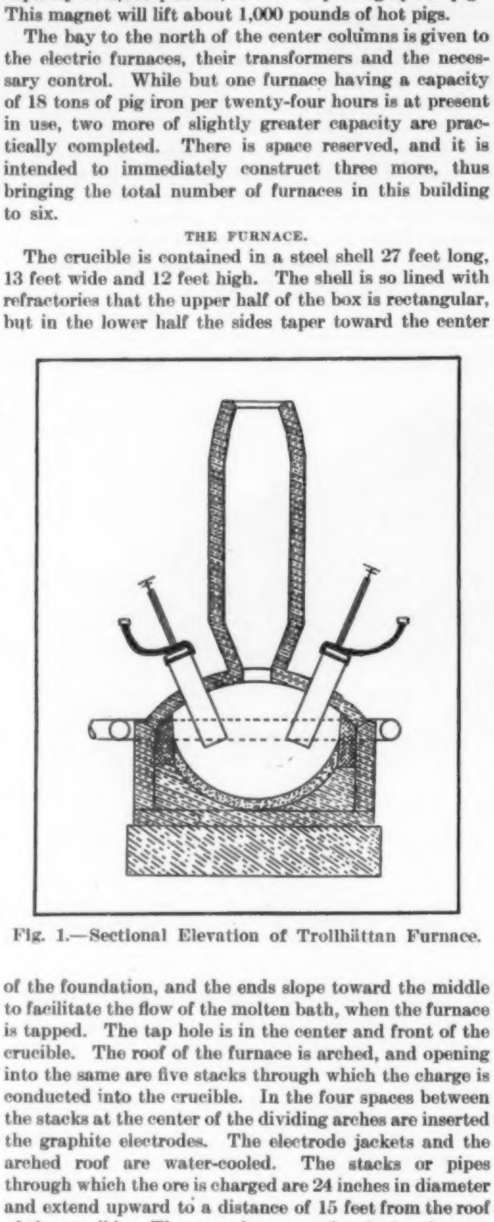


Fig. 1.—Sectional Elevation of Trollhättan Furnace.

of the foundation, and the ends slope toward the middle to facilitate the flow of the molten bath, when the furnace is tapped. The tap hole is in the center and front of the crucible. The roof of the furnace is arched, and opening into the same are five stacks through which the charge is conducted into the crucible. In the four spaces between the stacks at the center of the dividing arches are inserted the graphite electrodes. The electrode jackets and the arched roof are water-cooled. The stacks or pipes through which the ore is charged are 24 inches in diameter and extend upward to a distance of 15 feet from the roof of the crucible. These stacks are used only for the purpose of charging, no reduction being attempted in them. A charging platform is built along the top of the stacks and carries a track which runs to the mixing platform. Dump cars with the charge are run on the charging platform and dumped directly into the stacks. Except when receiving a charge, the stacks are closed with a tight-fitting cap.

THE ELECTRODES.

Graphite electrodes are used. They are cylindrical in form, 12 inches in diameter and 4 feet long. The upper end has a tapered male-threaded nipple, while the lower end has a corresponding socket with a female thread. As the electrode is fed into the charge a new one may be fastened to it, making a continuous feed.

An electrode lasts in continuous operation thirty days. Occasionally an electrode breaks in the furnace. This was formerly a serious matter and caused considerable delay and annoyance in the operation of the furnace. It was hard to determine just where the break had occurred, although it was generally at the threaded joint. A novel means has been devised by which the furnace men are now able to ascertain whether an electrode is broken or not. A bar is driven into the furnace opposite the electrode, through one of the several peep holes, and at the same time the electrode is tapped on top with a hammer. The man on the bar simply listens for the tapping. The tapping is then done on the bar and the man on the top listens. A break may be accurately located in this manner.

TRANSFORMERS.

In the rear of each furnace, and as close thereto as is possible, are the three service transformers which supply three-phase current at from 40 to 80 volts to the electrodes. These transformers are oil-immersed and water-cooled and have a capacity each of 750 kilowatts. The low-tension connections to the electrodes consist of eight pieces of flat copper bar, 3/8-inch thick and 5 inches wide, bolted together. On the 2,400-volt primary side there are brought out eight current taps for voltage regulation.

These are taken to an oil-immersed, individual solenoid-operated switch group, which, with auto-transformer compensator, gives fifteen steps for voltage variation.

ELECTRIC CONTROL.

Electric control is through a switchboard, there being a panel for each furnace. As the current and power-factor in each phase must be under observation at all times during operation, separate meters are installed in each phase. The requirements for one panel are three ammeters, three voltmeters, three wattmeters, three power-factor meters and three recording wattmeters. These are mounted across the panel in rows of three each. Under the first four sets named are three hand wheels to control the voltage variation, and under these three switches, which control the entire load, and still under these are the recording wattmeters.

For operating the voltage control and the main circuit breakers there is a 7 1/2 kilowatt motor-generator set, comprising a 125-volt direct-current generator, directly connected to a 10 horse-power induction motor. This set has a small panelboard mounting a circuit breaker, ammeter, voltmeter, and two single-pole knife switches. The transformers, switches, and control were supplied by the General Electric Company. In the event that line voltage should fall, or for any other cause, the direct-current supply should become deranged there is a National Storage Battery Company's set, having a capacity of 7 1/2 kilowatts, which may be instantly switched in, and thus prevent the furnaces from cutting out in the case of low voltage.

OPERATION.

In operation the furnace is continuous. After a period of eight hours the hearth contains a full bath of molten metal, and this is, therefore, tapped three times each day. Charging is done at regular intervals and the current is not shut off at any time.

During the period of smelting the change in electrical conditions is interesting. At the beginning of the charge the power-factor is almost unity. This gradually lowers as smelting continues, until with a full bath of metal a power-factor of about 5 per cent is reached. If coke is used in place of charcoal, or if a mixture is employed a different set of power-factor conditions exists. By studying these conditions it is possible to know the exact condition of the charge by looking at the meters. The load is, of course, a function of the voltage, and with half voltage the load will drop one quarter.

In charging, the ore cars are run on the mixing floor, which is at the same level as the charging floor. Cars with charcoal come into the lower part of the building and are hoisted on an electrically operated elevator to the mixing floor. Lime and quartz for flux are also brought in in cars, and each material is dumped into bins. The mixing is done in a car which is run on a platform scales. The charge is placed in layers, the proportions depending upon the tests made in the laboratory by the chemist. Following is a representative charge:

500 pounds iron ore (magnetite);
135 pounds to 150 pounds charcoal;
3 1/2 pounds lime (well burned);
12 1/2 pounds quartz.

COMPARISON OF THE CALIFORNIA AND SWEDISH FURNACE AND PROCESS.

As to the construction of the two types of furnaces, the difference is so apparent that no comment is necessary. As to the process, the California practice differs from the Swedish practice very decidedly in the following respects, namely:

1. No attempt at reduction in the stacks of the furnace.
2. Non-circulation of gases.
3. The use of limestone calcined outside the furnace.

In other words, the California practice is just the reverse of the Swedish practice, for in the latter they attempt reduction of the ore in the shaft of the furnace, they circulate a part of the gases escaping from the top of the shaft, and they do not use burned limestone.

REDUCTION IN SHAFT.

It would seem that the ideal condition in electric reduction furnace work would be to have the charge in such a condition as to only require melting by the time it comes in proximity to the electrodes. If this be done, the electric current is then only called upon to furnish the additional heat necessary to bring about the melting of the hot, previously reduced, oxide. Of course, the heat for the reduction must come from some source, and its origin would be in the crucible and as a result of the heat developed during the melting of the charge, but, as will be stated presently, the excess heat so developed can be transferred by the circulation of the gas to the charge in

the shaft and not carried away by radiation and an excessive amount of cooling water.

GAS CIRCULATION.

In the Swedish practice, a portion of the gases rising from the top of the shaft are returned to the crucible and made to pass through the same and up through the charge in the shaft. This is done for the following reasons:

1. To cool the superheated brickwork.
2. To carry up through the stack a sufficiently large volume of gas which has been raised to a high enough temperature to bring about reduction in the stack.

As has been previously pointed out in this article, one of the most serious difficulties that had to be overcome in the development of the Swedish type of furnace was the destruction of the crucible due to local heating in the vicinity of the electrodes. Therefore, by returning to the crucible a portion of the gases resulting from the reduction of the ore, it is possible to prevent excessive local heating and at the same time to make use of the heat instead of wasting it. This matter has been the subject of much discussion,[2] and has its objections, but the writer is of the opinion that its advantages in the way of economy of operation far outweighs its disadvantages. Perhaps it will in time be found practical not to use gas circulation in the electric iron reduction furnace, but, on the other hand, we believe that reduction previous to melting will be considered the proper practice, which means stack reduction, and the present California practice will not find application except in those instances where the local conditions warrant the same, as is the case at present. As has been pointed out, the present demand in California is for a soft gray foundry iron. The furnace now used gives that product, but this does not mean that such a construction and such a process are absolutely necessary for the production of such an iron. As a matter of fact, many tons of the same kind of iron were made at Heroult in a furnace of the Swedish type, and the Swedish inventors claim that it is possible to operate their type of furnace so as to reduce regularly an iron of the same character as is now produced at Heroult. They state, however, that in operating the furnace for this purpose the amount of electrical energy consumed per ton of pig produced is increased.

As to why the California type of furnace is better suited to the production of a soft gray foundry iron than is the Swedish type of furnace, it is probably due to the fact that reduction is performed solely by solid carbon in the crucible and as silicon is only reduced by solid carbon, its reduction to silicon takes place at the same time as that of iron oxide to metallic iron. The silicon is dissolved in the iron and by its presence causes the carbon to precipitate out as graphitic carbon, and there is thus obtained the soft gray iron desired. We are also of the opinion that in a furnace having a rectangular-shaped crucible, such as has the California furnace, the temperature of the charge in the crucible as a whole is much higher than is the case in a furnace of the Swedish type, and this higher temperature is more favorable to the reduction of silica to silicon, the latter, as before stated, being largely the controlling element in the production of soft gray foundry iron.

THE USE OF CALCINED LIMESTONE.

This has been repeatedly suggested, and theoretically it is the proper thing to do, but when operating a furnace of the Swedish type there are two objections to its use, namely:

1. It increases the percentage of fines in the charge.
2. It makes the charge hang.

As to the former of these objections, the idea seems to be more or less prevalent that there is no limit to the percentage of fines that may be used in the electric reduction furnace. We are not definitely informed in regard to this point with reference to the California practice, but judging from observations made upon the smelting of black sands, when the furnace consisted simply of a crucible and no shaft, more or less difficulty was experienced on account of the charge being made up entirely of fines. In the Swedish practice, the matter of the proportion of fines that can be used in a charge was definitely determined in the work at Trollhattän, and it was found that a large proportion of fines was detrimental to smooth running and good results, but Mr. Leffler, one of the engineers in charge of the work at Trollhattän, states that he is of the opinion that calcined limestone may be advantageously added to the charge if no reduction is attempted in the shaft.

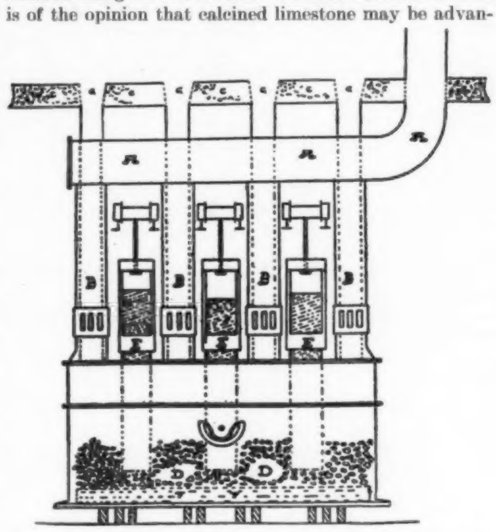


Fig. 2.—Heroult Three-phase Furnace for Smelting Iron Ore.

Summarized, then, we may say that the California practice as compared to the Swedish practice presents the following advantages:

1. Permits the use of limestone calcined outside the furnace.
2. Does not require the circulation of gases.

As to this latter point, and also as to reduction in the shaft, we are not sure but what the California practice would prove more efficient if both were done. Although a very full and complete record of the working of the furnace at Trollhattän has been published, such is not the case as regards the operation of the furnace at Heroult, and so it will not be possible to make a definite comparison of the two practices until it is possible to receive as definite information in regard to the working of the furnace at Heroult as is now available in regard to the operation of the furnace at Trollhättan.

LINES ALONG WHICH THE ELECTRIC FURNACE WILL PROBABLY BE IMPROVED.

The Size of the Unit.—In Scandinavia the furnace has gradually been increased in size until now there are 3,000 horse-power furnaces in operation and A. B. Elektrometall have completed a design for a 7,500-kilowatt furnace. Naturally the problem in connection with a furnace of the Swedish type is to get such an arrangement of the electrodes as to insure a practical uniform heating of the whole contents of the crucible, and at the same time maintain the electrical equilibrium of the power system.

It is quite certain that the Swedish type of furnace will be improved along this line, namely, increase in size of the unit, and it is for this reason that results obtained from the operation of a furnace designed for 7,500 kilowatts will be awaited with great interest.

As for the California type of furnace, it will no doubt be possible to indefinitely increase the length of the same, just as has been done with the modern rectangular copper blast furnaces.

EFFICIENCY.

The efficiency of the furnace will also be increased as time goes on, and probably by improvements along the following lines:

(*a*) The utilization of the waste gases.
(*b*) The securing of a high power-factor.
(*c*) The correction of induction losses.
(*d*) The further study of the single-phase furnace vs. the three-phase furnace.

As regards the latter, inasmuch as practically all large power installations are three-phase, it would seem that the only logical thing to do is to use three-phase current in electric furnace work, but from data submitted by Catania it would seem as if the mono-phase furnace is more efficient than the poly-phase furnace.

SUMMARY.

Summarized then, we may say that the electric iron reduction furnace has passed the experimental stage; that it is meeting the requirements in those localities where it has been introduced, and that it will no doubt find extended application in those countries where the conditions are favorable to its introduction, namely, where electric power is comparatively cheap and where coke and charcoal are comparatively high. Inasmuch as the cost of electric power is largely the governing factor in determining its adoption, and as the cost of electric power is constantly decreasing, we may expect to find an extended application of the electric reduction furnace in the future.

[2] "Gas Circulation in Electrical Reduction Furnaces," J. W. Richards, *Transactions*, American Electrochemical Society, Vol. XXI, page 403.

Some Mathematical Diversions*

By F. B. Selkin

There are many interesting recreations which consist in forming numbers by various combinations.

For example, write the number 45 as the sum of four numbers such as will give 10 as the result of adding 2 to the first of these numbers, subtracting 2 from the second, multiplying the third by 2 and dividing the fourth by 2.

$$8+12+5+20=45$$

Answer: $8+2=10 \quad 5\times 2=10$

$12-2=10 \quad 20\div 2=10$

Another problem of this type is that of forming the number 225 by the addition of integers composed of the nine significant digits each taken once.

Answer: $225=1+23+45+67+89$

We should notice that in the preceding case each new addend is formed by adding 22 to the preceding one. All numbers which, like 225, can be decomposed into addends composed of the nine significant digits must be multiples of nine, since the sum of the nine significant digits is a multiple of nine. For example, 100 not being a multiple of nine cannot be obtained by a similar addition.

There are several other problems which involve the use of the nine significant digits. One of the favorite ones is the following. To write the number 100 using all nine significant digits. Fourrey in his "Récréations Scientifiques" gives many answers to this problem.

$$\begin{aligned}100&=1+2+3+4+5+6+7+8\times 9\\&=74+25+\tfrac{3}{6}+\tfrac{9}{18}\\&=95+4+\tfrac{38}{76}+\tfrac{1}{2}\\&=98+1+\tfrac{3}{6}+\tfrac{27}{54}\\&=91\tfrac{5742}{638}\\&=91\tfrac{7524}{836}\\&=91\tfrac{5823}{647}\\&=94\tfrac{1578}{263}\\&=96\tfrac{1428}{357}\\&=96\tfrac{2148}{537}\\&=96\tfrac{1752}{438}\end{aligned}$$

In Ball's "Récréations Mathématiques" we find the following additional results:

$$\begin{aligned}100&=50+49+\tfrac{1}{2}+\tfrac{38}{76}\\&=78+15+\sqrt{9}\sqrt[3]{64}\end{aligned}$$

Lucas in "L'Arithmétique Amusante", p. 847, adds the two following:

$$\begin{aligned}100&=97+\frac{5+3}{8}+\tfrac{6}{4}+\tfrac{1}{2}\\&=75+24+\tfrac{9}{18}+\tfrac{3}{6}\end{aligned}$$

There is another interesting puzzle connected with the number 100. To write 100 as the sum of four numbers such that 4 added to the first, subtracted from the second, multiplied by the third, and used as divisor for the fourth, gives the result 16.

Answer: $100=12+20+4+64$

$12+4=16 \quad 4\times 4=16$

$20-4=16 \quad 64\div 4=16$

Still another puzzle connected with the number 100 is that of writing 100 with a single digit repeated five times. There are several possibilities.

$$\begin{aligned}100&=111-11\\&=5\times 5\times 5-5\times 5\\&=3\times 33+\tfrac{3}{3}\\&=(5+5+5+5)\times 5\end{aligned}$$

Schäfer gives the following puzzles involving the number 100: To write 100 without using zeros.

Answer: $100=99\tfrac{4}{4}$

To write 100 with four 9's: $99\tfrac{9}{9}=100$

To write 100 with six 9's;. $99\tfrac{99}{99}=100$

We find several interesting puzzles centering about the number 9. For example, to write the number 9 using all ten digits of the decimal system each appearing but once.

$$\begin{aligned}9&=\frac{97524}{10836}\\&=\frac{95823}{10647}\\&=\frac{95742}{10638}\end{aligned}$$

It is possible to write the number 1 using all ten digits as follows:

$$1=\frac{35}{70}+\frac{148}{296}$$

Another interesting problem is that of writing 31 using five 3's.

$$31=3+3^3+\tfrac{3}{3}$$

The following is a similar problem: To write 34 using four 3's we may write,

$$33+\tfrac{3}{3}=34$$

We may write the number 14 with five 1's and the number 13 with four 1's as follows:

$$\begin{aligned}14&=1+1+1+11\\13&=11+1+1\end{aligned}$$

A very puzzling problem is that of finding the largest number that can be written with three digits. The answer we are likely to obtain is 999, whereas the correct answer is 9^{9^9}.

* Reproduced from the *Teachers' College Record*

The Elimination of Smoke*

By D. F. Crawford

The largest proportion of the smoke emitted in any locality where bituminous, or soft coal, is generally used may be attributed to one source—that is, the stationary boiler, which supplies the steam power for so many purposes.

From a point of vantage in almost any city on a cool morning a glance around the horizon will disclose the vapor of steam arising from many buildings, including, with those used for strictly manufacturing purposes, many hotels, office buildings, stores and apartments. At practically every point where this vapor is observed there is a possible source of smoke emission.

Where any considerable quantity of smoke arises from sources such as mentioned, it may generally be attributed to one cause, namely, the capacity of the boiler plant is insufficient for the work imposed on it.

To illustrate, if a boiler having a capacity of, say, 100 horse-power, is not loaded beyond 75 horse-power there is little probability of smoke, unless the plant is very carelessly handled. If loaded to its rated capacity, with careful handling, but little, if any, objectionable smoke will be produced. However, if the boiler be loaded beyond its capacity it is difficult, if not impossible, so to handle it as to prevent objectionable smoke.

The greater part of the smoke emitted in any of the larger cities may be eliminated by insisting that the owners of manufacturing plants and other classes of buildings mentioned provide boilers of adequate capacity.

Next in importance as smoke producers are the many fires used in a city for domestic purposes. Each individual fire produces only a small quantity of smoke but in the aggregate their contribution to the smoke annoyance is very large indeed; in some cities the smoke and gases from this source exceed that from all others.

It is a matter of record that the heaviest black fogs in London occur on Sundays and Christmas Day, or other holidays when the manufacturing plants are closed. While the smoke from fires used for domestic purposes does not attract the attention as much as that from a large plant, the effect on objects with which it comes in contact is greater, on account of the fact that the smoke from small slow fires contains considerably more tarry matter than that from large fires burning at high temperatures. The soot contained in this tarry matter adheres more firmly to the buildings, people, clothing, etc., than does the soot which consists principally of carbon coming from fires of greater intensity.

In the cities which are adjacent to rivers, lakes or harbors a considerable proportion of the annoying smoke comes from the water craft, where the problem of producing a large amount of power with limited space tends to make the boiler plants small in comparison with the work required.

While it is true that locomotives produce a certain proportion of the smoke in localities where they are used, it is a fact that if all of the locomotives in use were to cease making smoke, but twenty to forty per cent of the smoke in cities such as Philadelphia, Chicago, Cleveland and Pittsburgh would be eliminated, leaving from sixty to eighty per cent of the smoke now existing to trouble us.

The railways of America produce transportation of passengers and freight at the lowest cost of any in the world, and to obtain this result large locomotives, and consequently large coal consumption, is necessary, and large coal consumption with comparatively small boilers means smoke, as before explained.

The dimensions of the locomotive boiler must be confined to the permissible limits of width and height clearance; its length must be made to conform to the limit of practicability, and for these reasons it is impossible to increase the capacity of the boiler; the further reason that the public demands rapid and luxurious transportation makes it impracticable to reduce the work required of each unit.

The railways are most vitally interested in the elimination of smoke for economic reasons, for, while smokeless combustion does not always mean economy, combustion with heavy smoke always indicates loss, and as many millions of dollars are spent annually for coal, even a small saving per locomotive would make a large sum in the aggregate.

The property of the railway adjacent to the tracks, such as station, bridges, signals, telegraph lines, etc., is damaged and deteriorated by smoke, requiring large expenditures for renewals, as well as for maintenance, such as painting and cleaning.

The possibility of largely reducing the expenses for the items above mentioned, without reference to the viewpoint of aesthetic or personal comfort, has been a sufficient incentive to cause the railway people to give the smoke subject a large amount of consideration.

The railway officers and employees suffer the annoyance caused by locomotive smoke to the same or even greater extent than do the patrons or others who are located near the tracks, as their occupation requires almost continuous proximity to the smoke source.

This personal interest, the interest of the community, added to the possibility of the savings mentioned above, has led to almost continuous study of the locomotive smoke problem. This study has extended over twenty-five years to my personal knowledge, and from the records, many years farther back.

During the last fifteen years I have examined drawings and patents of many devices which were supposed to eliminate smoke, and made personal observations of their performance. Unfortunately, but very few of these were even promising, and if worthy of installation and trial, the results obtained were not such as to warrant using the apparatus in regular service.

The Pennsylvania Railroad System has devoted a great deal of attention, and expended a large amount of money in experimenting with and developing, either on its own account, or in co-operation with representatives of other railways, or the technical societies, devices which gave promise of reducing the smoke from locomotives, and in 1910 the management sent a committee of three to Europe to study conditions and results obtained with the various devices and methods in use there, for comparison with the practice in this country.

For many years devices designed to admit steam or air into the locomotive fire-box have been used as a means for reducing smoke, with generally unsatisfactory results.

During the past year, however, a device for supplying air to the fire-box was developed and subjected to rigid and painstaking scientific study. Tests were made at the locomotive testing plant of the Pennsylvania Railroad, and the results were confirmed by carefully watching the performance of the locomotives in regular service. This device considerably reduces the amount of smoke under some conditions, and the results obtained so far are sufficiently promising to permit extending its use, especially for the smaller locomotives.

During the past nine years there has been developed on the Pennsylvania lines west of Pittsburgh, a device which, up to the present time, is the most promising yet produced for the reduction of smoke, and in fact under favorable conditions, the practical elimination of locomotive smoke. I refer to the locomotive stoker, with which one hundred and fifty-four locomotives have been equipped, and one hundred and forty more are under construction.

With this stoker we have succeeded in greatly reducing the amount of smoke emitted by locomotives in heavy passenger train, freight and switching service. Repeated comparisons of the smoke made by locomotives with and without the stoker show that those equipped with the stoker may be operated with from one tenth to one fourth of the smoke made by similar locomotives in the same service without the stoker.

As stated above this is the result of nine years' experimentation and development, but now, while the apparatus is sufficiently developed to warrant the trial of a large number, the problem of maintaining, and satisfactorily operating them, with various kinds of coal, is still before us.

What does this mean to you as to reducing the annoyance from locomotive smoke? Only this—that there are now in existence two devices for reducing the smoke from locomotives which are sufficiently promising to make it probable that the use of them will be extended, and that the information obtained from them is likely to lead to the development of others.

In addition to the study and development of mechanical devices for the elimination of smoke, the railways, by additional supervisors and instructors, are causing reduction in the amount of smoke emitted, by having more careful firing and handling of locomotives by the enginemen, and are making a comprehensive study of the problem of reducing the amount of smoke about engine houses, where fresh fires are made, the smoke from which is the most difficult to control.

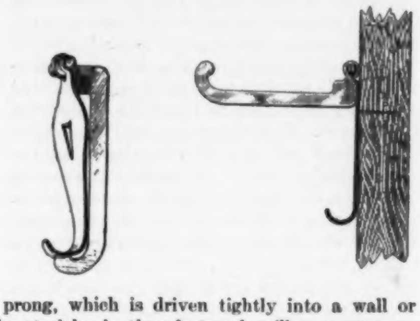
All of this shows that the railways are keenly interested in this subject, and in addition thereto the American Railway Master Mechanics Association has a committee studying the problem, and the railways are also co-operating with the various other associations, and city officials interested.

Of course, one way to eliminate locomotive smoke would be to eliminate the steam locomotive by substituting electric motors. No doubt from time to time the use of electricity will be extended but it must be borne in mind that to do so will require tremendous outlay of capital for the installation, and it does not yet appear, except under the most favorable circumstances, that the expenditure will be warranted by the returns. Further, if the railways are electrified there will still remain from sixty to eighty per cent of the existing smoke to be dealt with.

* Lecture delivered at the New Century Club.

Pocket Clothes Hanger

This device, which is shown in about half size in the illustrations, consists of wooden and steel hooks, united by a pivot. The steel hook is stamped from a plate of steel, and a sharp-pointed tongue, formed by two incisions in its central portion, is bent backward to form



a prong, which is driven tightly into a wall or door. The steel hook, thus fastened, will support a considerable weight. The wooden hook, which is supported by the rivet and is kept horizontal by the pressure of its knee against the door or wall, is used for the hat and other light articles.

SCIENTIFIC AMERICAN SUPPLEMENT

Founded 1876

NEW YORK, SATURDAY, JUNE 14, 1913

Published weekly by Munn & Co., Inc., Charles Allen Munn, President
Frederick Converse Beach, Secretary and Treasurer;
all at 361 Broadway, New York

Entered at the Post Office of New York, N. Y., as Second Class Matter

The Scientific American Publications

Scientific American Supplement (established 1876)	per year	$5.00
Scientific American (established 1845)	"	3.00
American Homes and Gardens	"	3.00

The combined subscription rates and rates to foreign countries including Canada, will be furnished upon application.

Remit by postal or express money order, bank draft or check

Munn & Co., Inc., 361 Broadway, New York

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